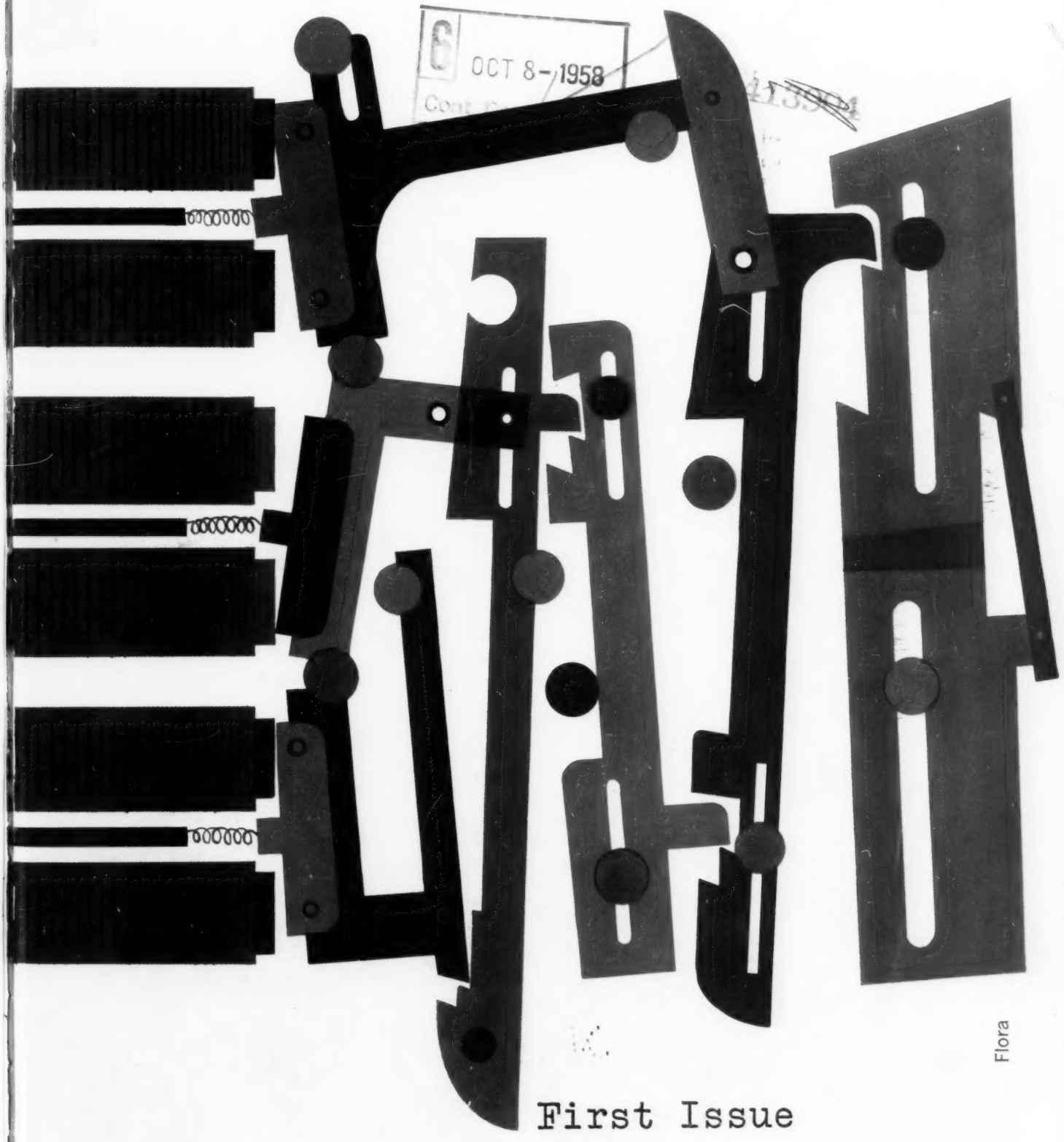
ELECTROMECHANICAL components & systems DESIGN

1

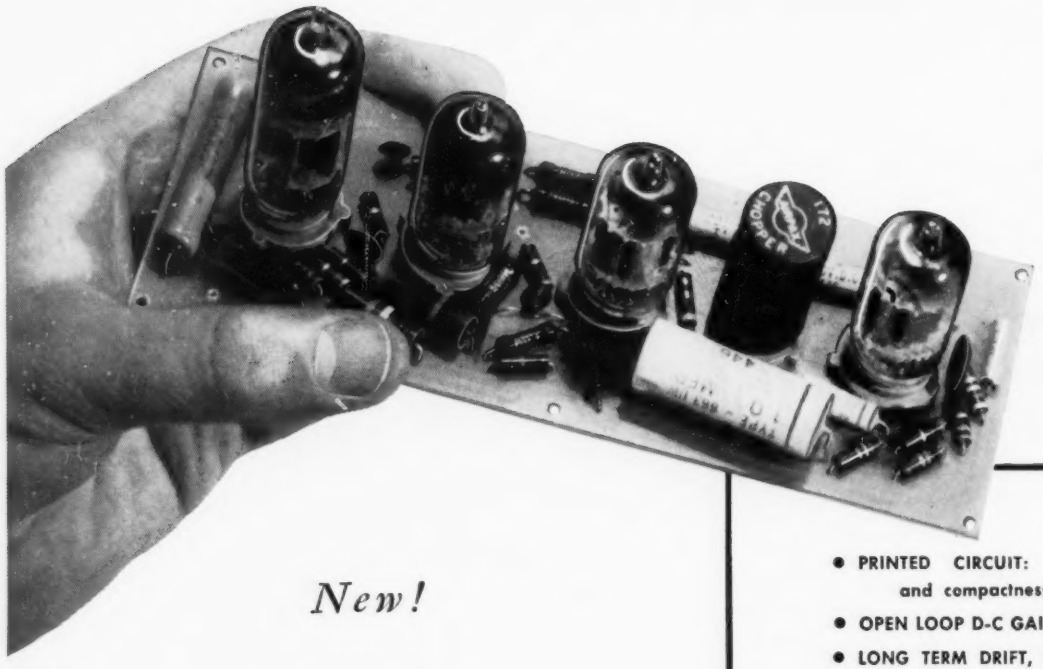
SEPTEMBER-OCTOBER 1957

6 OCT 8-1958



Flora

First Issue



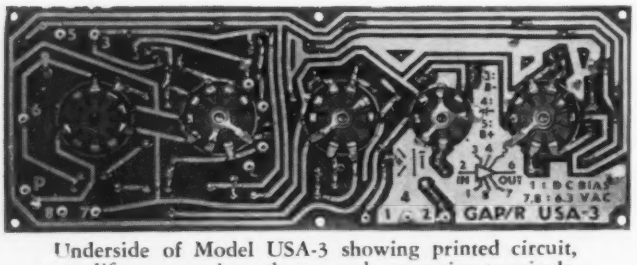
New!

Greater System Accuracy

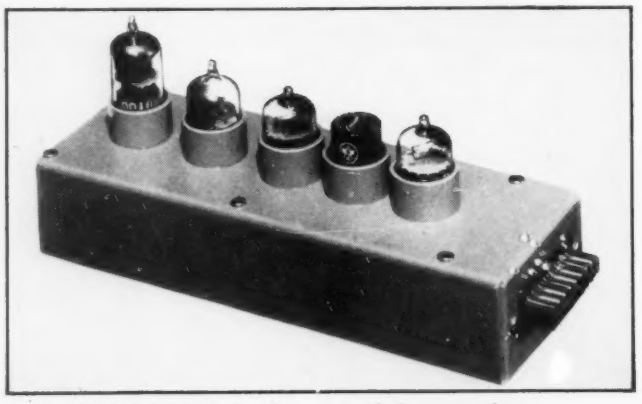
and Reliability with the

- PRINTED CIRCUIT: Economy, reliability and compactness.
- OPEN LOOP D-C GAIN: 10 million.
- LONG TERM DRIFT, NOISE and OFFSET: under 100 microvolts.
- OUTPUT VOLTAGE RANGE: ±115 volts.
- SIZE: 7" x 2½" board.
- MOUNTING: Any convenient method.
- PRICE: $95.00.

PHILBRICK *PRINTED CIRCUIT* AMPLIFIER



Underside of Model USA-3 showing printed circuit, amplifier connection scheme, and connecting terminals.



Model USA-3 showing one of the several types of modular packaging available at extra cost.

Model USA-3

High performance combined with the reliability and compactness of a printed circuit design are featured in the new Philbrick Universal Stabilized Amplifier, Model USA-3. It is ideally suited for applications to instrumentation, control and analog computation. Extremely high open-loop d-c gain, wide bandwidth, low noise and wide output range are important performance characteristics of this new chopper stabilized amplifier. An interesting design feature makes this instrument safe against self-destruction, even under prolonged overload conditions or direct grounding of its output. At a price of only $95.00, it offers more performance per dollar than any other amplifier on the market today. *Write to George A. Philbrick Researches, Inc., Dept. 19, for Bulletin USA-3.*

GEORGE A.
PHILBRICK
RESEARCHES, INC.
230 Congress Street, Boston 10, Massachusetts

FOR MORE INFORMATION CIRCLE 111 ON INQUIRY CARD

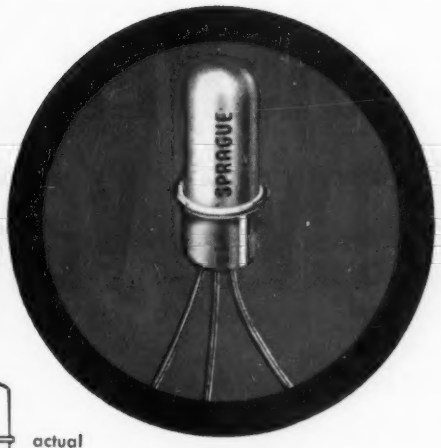
surface barrier transistors from SPRAGUE

2N344/SB101
for Medium Gain Amplifiers

	Min.	Typ.	Max.
h_{fe}	11	23	83
f_{max}	30	45	—

2N345/SB102
for High Gain Amplifiers

	Min.	Typ.	Max.
h_{fe}	25	40	110
f_{max}	30	45	—



actual size

2N346/SB103
for High Frequency Oscillators

	Min.	Typ.	Max.
h_{fe}	10	—	—
f_{max}	60	90	—

2N240/SB5122
for Computer Switching

	Min.	Max.
h_{fe}	16	—
f_{max}	30	—
T_s	—	80

IN VOLUME PRODUCTION *Now!*

For general high frequency applications, and for high speed computer switching circuits, design around Sprague surface barrier transistors. They are available now in production quantities from a completely new, scrupulously clean plant, built from the ground up especially to make high quality semi-conductor products.

The four transistor types shown are the most popular. Orders for these units are shipped promptly. What's more, surface barrier transistors are reasonably priced. High quality and excellent electrical characteristics make them an economical solution to many difficult circuit requirements.

Sprague surface barrier transistors are fully licensed under Philco patents. All Sprague and Philco transistors having the same type number are manufactured to the same specifications and are fully interchangeable. You have *two* sources of supply when you use surface barrier transistors!

WRITE FOR COMPLETE ENGINEERING DATA SHEETS ON THE TYPES IN WHICH YOU ARE INTERESTED. ADDRESS REQUEST TO THE TECHNICAL LITERATURE SECTION, SPRAGUE ELECTRIC CO., 459 MARSHALL ST., NORTH ADAMS, MASS.

SPRAGUE®
the trademark of reliability

TRANSISTORS • RESISTORS • MAGNETIC COMPONENTS
CAPACITORS • INTERFERENCE FILTERS • PULSE NETWORKS
HIGH TEMPERATURE MAGNET WIRE • PRINTED CIRCUITS

FOR MORE INFORMATION CIRCLE 1 ON INQUIRY CARD

DESIGNER'S FAVORITE SENSITIVE, VERY RESPONSIVE

Thermoswitch® Is Rugged, Adaptable, Heat Controller

ASHLAND, MASS. — Word emanating from here is that Fenwal Incorporated's THERMOSWITCH units are usually the best solution for a design engineer with temperature-control problems.

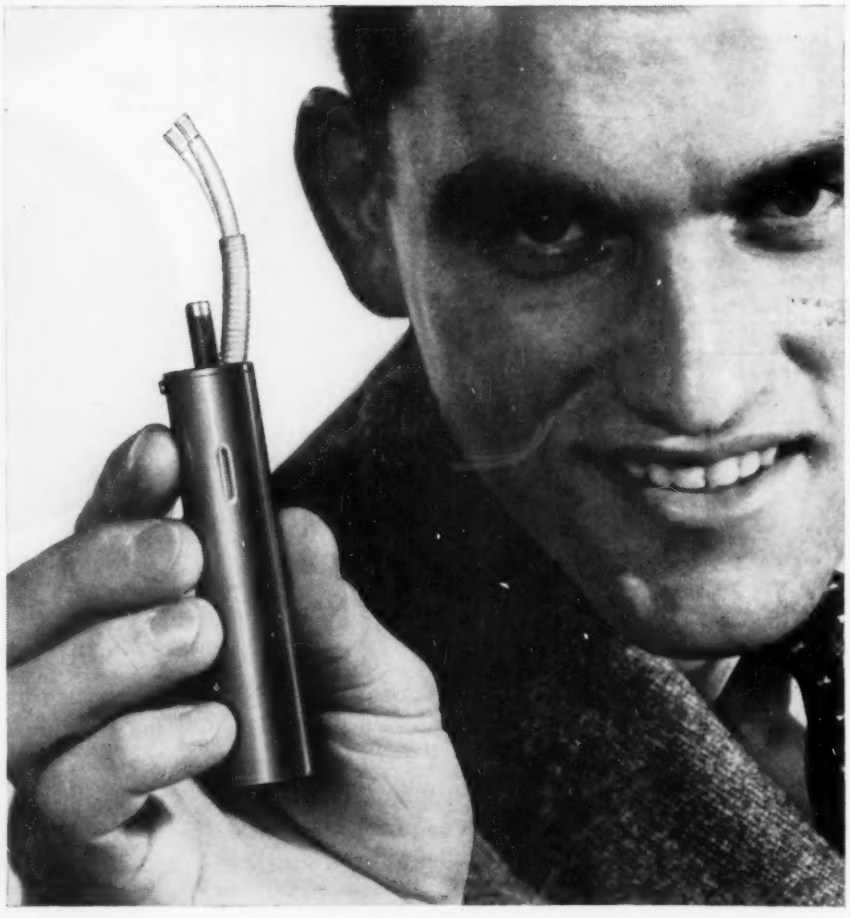
THERMOSWITCH thermal controls are adaptable, sensitive, responsive, small, tough, and accurate — and their price is right. They frequently replace controllers costing much more, and do a better job.

Their principle of operation is unique — and highly competitive in terms of every quality most design engineers would require. The unique principle is this: *the activating control element is a single-metal shell that expands or contracts instantaneously with temperature changes, making or breaking the totally-enclosed electrical contacts.*

Design engineers have put THERMOSWITCH units to work everywhere that temperature control is vital — in planes . . . factories . . . ships . . . hospitals . . . food-processing plants . . . homes . . . laboratories. The list of THERMOSWITCH applications is virtually endless. So is the list of physical ordeals the units have survived and the high performance standards they've met.

When tested alongside bulb-type and enclosed bi-metallic thermostats under identical conditions, THERMOSWITCH units have overwhelmed both with performances like these:

- reaction speed, four to nine times as fast;
- heat-responsive area, three to six times as large;
- heat-transfer path, only one-third to one-sixth as long;
- temperature differential, only one-tenth to one-nineteenth as great;
- vibration-sensitivity, only one-twelfth to one-eighteenth as great;
- shock-sensitivity, only one-tenth to one-eighteenth as great;



FENWAL THERMOSWITCH UNITS may solve your temperature control problems, too. Sensitive, tough, and accurate — they have been put to work by designers wherever temperature control is vital. Over 25,000 variations of the THERMOSWITCH unit are available. Write for THERMOSWITCH folder.

Added to these points of superiority are such demonstrable features as uniformity of sensitivity throughout the operating range, built-in temperature anticipation, enclosed tamper-proof assembly, direct radiant heat reception, and an operating range from −100°F. to 600°F.

Other ranges are available, too. The point at which a unit makes or breaks a circuit is determined by a set screw easily adjusted in the field.

There's a Fenwal sales engineer ready to help you apply THERMOSWITCH units to your particular heat control problems — ready with over 25,000 variations. Write Fenwal for his name and for complete specifications. **Fenwal Incorporated 109 Pleasant Street, Ashland, Mass.**

Fenwal

CONTROLS TEMPERATURE ... *PRECISELY*

FOR MORE INFORMATION CIRCLE 2 ON INQUIRY CARD

Staff

Editor and Publisher	Harold G. Buchbinder
Managing Editor	Robert B. Brotherston
Associate Editor	Andrew R. MacAndrew
Associate Editor	Charlotte Kaizer
Staff Columnists	David Bandel Renato Contini Jesse E. Hobson Israel Katz Emile Labin Ronald C. Vickery
Special Projects Editors	Martin Kagan David I. Kosowsky Saul Padwo
Contributing Editors	Herbert K. Brown H. Donald Conway Oliver Haywood Herbert Kaizer George King
Ass't. to Publisher	Ruth Robinson
Editorial Assistants	Claire Connelly Anna Di Palma
Advertising Production	Doris Karal Elinor Cohn
Production and Technical Art	Peter Mehlich Organization
Art Director	James Flora
Director of Circulation	A. Allen Binder
Business Manager	Benjamin Robert Payn

Offices

NEW YORK
405 E. 54th St.
New York 22, N. Y.
Eldorado 5-0132
Milton Berns
Richard Aiken

NEW ENGLAND
1357 Washington St.
West Newton 65, Mass.
Bigelow 4-9006
George Palken

CLEVELAND
5322 Kennedy Ridge
North Olmstead, Ohio
Spring 7-0040
Donald Murray

DETROIT
3133 Ewald Circle
Detroit, Michigan
Texas 4-1989
Ralph Verlaine

WEST COAST
6535 Wilshire Blvd.
Los Angeles, Calif.
Olive 3-3223
James C. Galloway

PUBLISHED MONTHLY FOLLOWING THIS SEPTEMBER-OCTOBER ISSUE AND A NOVEMBER-DECEMBER ISSUE BY BENWILL PUBLISHING CORPORATION, BENJAMIN ROBERT PAYN, PRESIDENT; HAROLD G. BUCHBINDER, EXECUTIVE VICE PRESIDENT; MILTON BERNS, GEORGE PALKEN VICE PRESIDENTS. EXECUTIVE OFFICE: 405 EAST 54TH STREET, NEW YORK 22, N.Y. TELEPHONE: ELDORADO 5-0132. EDITORIAL AND SUBSCRIPTION OFFICE: 1357 WASHINGTON ST., WEST NEWTON 65, MASS. TELEPHONE: BIGELOW 4-9006. APPLICATION FOR ACCEPTANCE AS CONTROLLED CIRCULATION PUBLICATION PENDING AT ORANGE, CONN.

ELECTROMECHANICAL COMPONENTS & SYSTEMS DESIGN IS CIRCULATED WITHOUT CHARGE UPON REQUEST TO QUALIFIED RESEARCH, DEVELOPMENT AND DESIGN ENGINEERS IN ALL BRANCHES OF INDUSTRY IN THE CONTINENTAL UNITED STATES INCLUDING GOVERNMENTAL AND UNIVERSITY INSTALLATIONS. OTHER SUBSCRIPTIONS: CONTINENTAL U.S. $5.00 PER YEAR; SINGLE COPY, $1.00 WHEN AVAILABLE.

Postmaster: send form 3579 to
Benwill Publishing Corporation
1357 Washington St.
West Newton 65, Mass.

Publisher's Prospectus

For years Industry teamed the electronic designer with the mechanical designer so they could develop together what each could not produce alone. From this merger and from company-sponsored training programs has come the electromechanical engineer—you, the designer who combines ideas and techniques from both fields into new and improved products for industry, the military and the consumer.

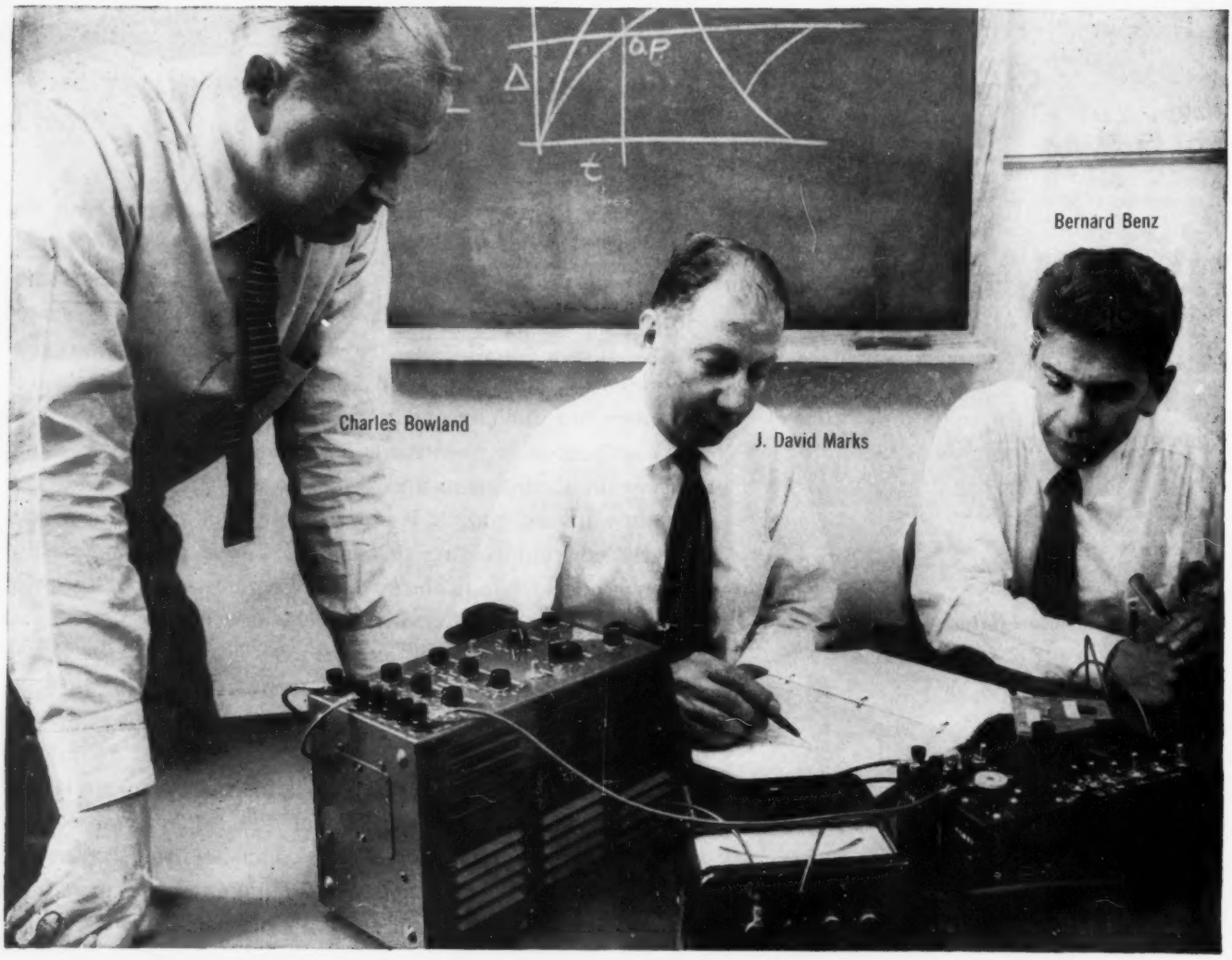
Your success is phenomenal. The merger of electronic and mechanical components and parts into unified systems, expanding by leaps and bounds, is now evident in all kinds of products. Today, few engineering problems that have been approached from either the purely electronic or the purely mechanical point of view are considered adequately surveyed. Tomorrow, no doubt, the universities will offer courses leading to a Bachelor's Degree in Electromechanical Engineering.

The editorial objective of this new magazine is simply to function for you as a source-book of ideas and techniques in electromechanical research, development, design and their management. To assist our editorial staff, we have a board of contributing editors, special project editors and staff columnists. Each of these men is currently working in industry in some phase of electromechanical research, development and design; each has reached a position of authority and responsibility in the management of these functions. All of us are, in a sense, your consultants as we uncover your professional needs and attempt to meet them in the pages of this publication.

HAROLD G. BUCHBINDER
Editor and Publisher

SUBSCRIPTION POLICY

This first issue of ELECTROMECHANICAL components & systems DESIGN has been sent to you in your name and title at your company address. You can insure your receiving a year's complimentary subscription by taking a few moments to fill one of the prepaid post cards facing our inside front or back cover. Should you have received this first issue from a colleague and both cards are missing, you can still take advantage of this complimentary offer by requesting it on your company letterhead. Complimentary subscriptions will only be sent to you at your company address. Home subscriptions are available if requested on company letterhead at a subscription cost of five dollars per year.



an important G-V specialty . . .
SOLVING THERMAL RELAY PROBLEMS

These Application Engineers study each proposed new use of thermal relays, select the relay best suited for the job, and test the relay under your conditions to tell you exactly what it will do. They can choose from more than 1,000 variations of the G-V thermal relay line which are available as standard items, at no additional cost and on dependable delivery schedules. With these standard relays, they solve over 98% of all thermal relay problems submitted to us.

The occasional user who needs a special design finds the separate G-V Research and Development Staff ready to apply their experience and ingenuity to the design of a new unit.

Complete reliability in all G-V products is assured by certified qualification testing in the G-V Environmental Test Laboratory under the most severe conditions found in field use.

These are just some of the reasons why the country's leading manufacturers of aircraft and electronic equipment have used more than a half million G-V Thermal Time Delay Relays...Hot Wire Time Delay Relays ...Voltage and Current Sensing Relays...finding them more reliable and more economical than any other.

Well-qualified G-V representatives, backed up by Regional Field Engineers, are ready to serve you anywhere in the U. S. or Canada. Complete catalog data on G-V Relays and Thermostats is available.

G-V CONTROLS INC.

58 Hollywood Plaza, East Orange, New Jersey

FOR MORE INFORMATION CIRCLE 3 ON INQUIRY CARD

SEPTEMBER-OCTOBER 1957

VOLUME 1 • NUMBER 1

ELECTROMECHANICAL components & systems DESIGN

CONTENTS

COMPONENTS DESIGN

12 HIGH FREQUENCY CRYSTAL FILTERS
New solutions for design problems in communication, navigation and other commercial and military systems

18 ELAPSED TIME INDICATOR
Novel design approach in miniaturization

20 ELECTROMECHANICAL PHASE GENERATOR
Phase shifting without tubes or transistors

28 CONTROLLABLE INDUCTORS
Switching ideas and techniques for radio frequency circuits

SYSTEMS OF COMPONENTS

42 AIR DATA COMPUTER
Balanced-force system design in analog computation

45 ELECTRONIC FIBER FINENESS INDICATOR
New solution for an old problem in the textile industry

50 FURNACES FOR SEMICONDUCTORS
The secret of furnace design for a rapidly changing product

52 DIGITAL READOUT PRINTER
Solenoid-lever design converts voltage pulse to lateral motion

56 PREVENTIVE ENGINEERING
De-icer detects symptoms of impending ice formation

60 MISSILE TRACKING
Film transport and shutter phasing designs take the bounce out of the camera

PRODUCTION TECHNIQUES

74 PRINTED WIRING DESIGN
New photographic technique for designers

80 ULTRASONIC DRILLING
Now applied to intricate ceramic parts

84 ELECTROFORMNG
New latitudes in design

DESIGN TIME SAVER

88 PRECISION COMPRESSION SPRING DESIGN
A logical step-by-step procedure that eliminates tedious calculation

RESEARCH

98 SUPERCONDUCTIVITY
Applications now possible in electronic circuits

MANAGEMENT

106 TRANSITIONS
Training aids in converting the engineer to a supervisor

108 SEMINARS FOR ENGINEERS
Cutting costs and influencing output

112 ENGINEER EVALUATION
Correlations vs haloes

120 THE ENGINEERING SHORTAGE
Statistics vs opinion

ADVERTISING INDEX 123

STAFF COLUMNISTS

Ronald C. Vickery 34 THE CHEMISTRY OF COMPONENTS
Rare earth storage batteries and ferrites?

Israel Katz 66 THE HEART OF THE MATTER
A challenge to design resourcefulness in military flight vehicles

Jesse E. Hobson 104 ORGANIZING FOR RESEARCH

Renato Contini 116 HUMAN FACTORS IN DESIGN

Emile Labin 118 REPORT FROM FRANCE

Martin E. Kagan 127 WESCON: FATTED CALF AT THE COW PALACE

MINING
in the sky

Brush Oscillographs instantaneously chart and coordinate aerial exploration data; save engineering dollars

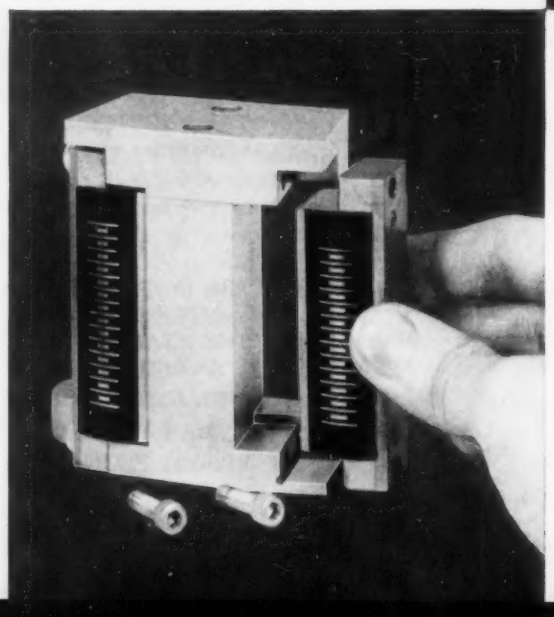
With a portable six channel Brush Oscillograph mounted in a helicopter, Aero Service Corporation visually checks significant data in flight—saves time in locating deposits of minerals or oil. This instrumentation can save money for you.

The helicopter is equipped with detecting instruments sensitive to different materials. A magnetometer responds to magnetic ores and oil-bearing formations. An electro-magnetic detector locates electrically conductive sulphides, and a scintillation counter checks radioactive elements.

The Brush system records output of all three instruments, plus the altimeter, on a single chart to provide a running record of tests. This system saves time presenting results in permanent chart form.

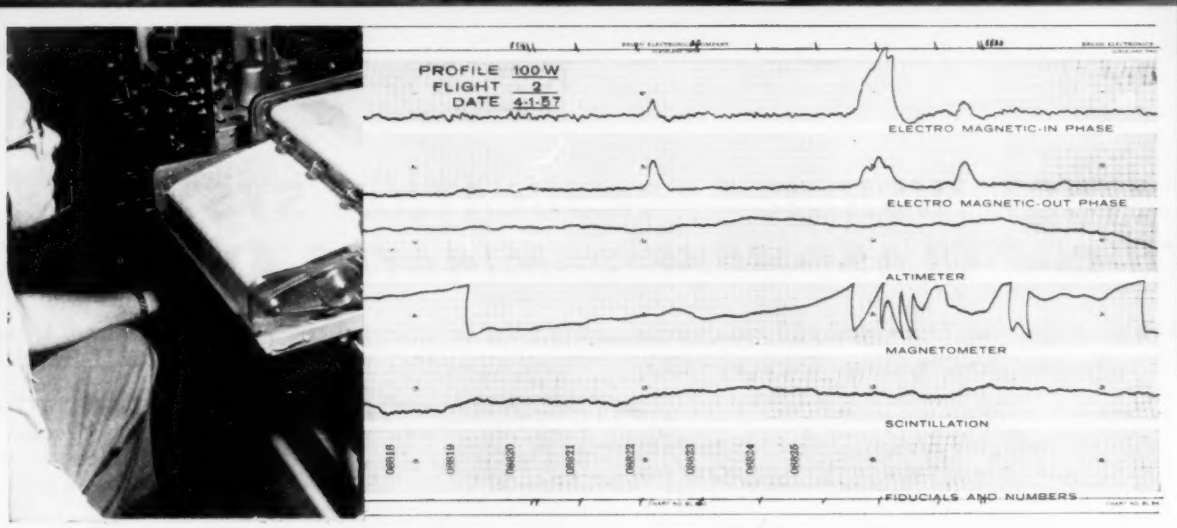
The Brush direct-writing frequency range, from d.c. to 100 cycles per second, covers all requirements of this application . . . and of 90% of the physical measurements throughout industry. Brush offers complete direct-writing systems for portable or rack use, for recording one to eight channels of data, with a wide range of chart speeds.

Use this instrumentation to save engineering time.



NEW DEVELOPMENT IN MAGNETIC HEADS—

Interlacing two 14-channel heads provides 28 channels, but demands careful alignment. To simplify mounting, Brush now offers an integral block interlace head. Exact relative alignment is provided by the mounting block.



Brush Oscillograph system in plane maintains accuracy despite rugged use and environmental extremes. Six channel chart records output of magnetometer, electromagnetic detector, scintillation counter, and altimeter. This instrumentation is ideal for *your* field test operations.

Write Dept. M-11 for further information.

BRUSH ELECTRONICS COMPANY

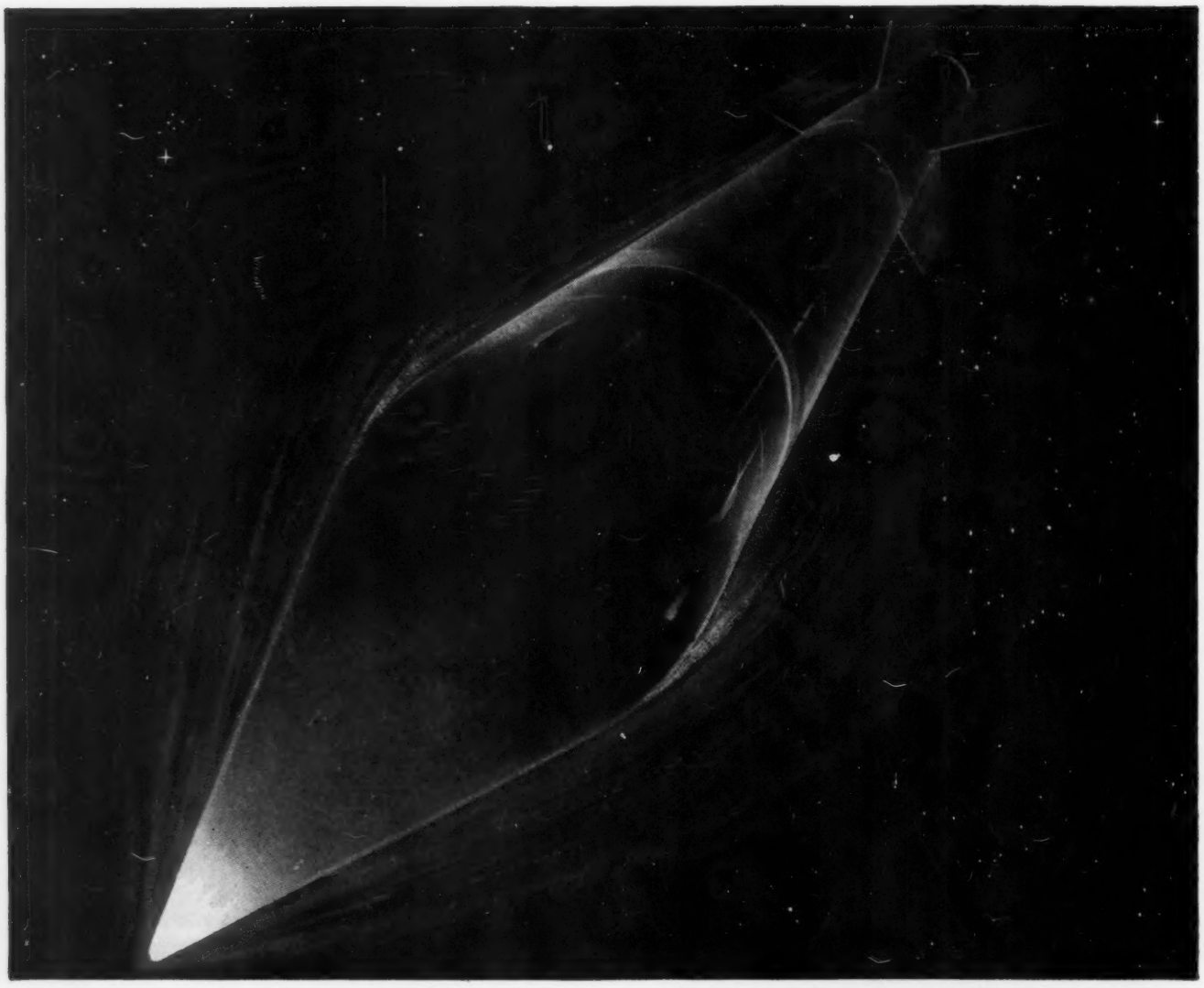
3405 Perkins Avenue, Cleveland 14, Ohio

BRUSH ELECTRONICS

DIVISION OF CLEVITE CORPORATION

OSCILLOGRAPHIC RECORDING SYSTEMS • SOUND INSTRUMENTATION • MAGNETIC COMPONENTS • PIEZOELECTRIC MATERIALS • WEAPONS SYSTEMS

FOR MORE INFORMATION CIRCLE 4 ON INQUIRY CARD



Sustained operating temperatures up to 400° F, as in guided missiles, are death to inferior electrical insulations and laminates. CDF glass-base laminates of Teflon*—the only laminates of their kind approved by the military—can take this punishment steadily.

LATEST HIGH-HEAT INSULATION SYSTEMS NEED CDF GLASS-BASE LAMINATES AND TAPES

Widest available range offers Teflon, epoxy, silicone, mica products for dimensional stability under continuous heat

As components and equipment grow smaller, and heat becomes more difficult to dissipate, CDF high-heat electrical insulations become increasingly important to electronic design. For nowhere else can such a wide range of quality insulations be found under one roof as at CDF.

FOR HIGH-HEAT PRINTED CIRCUITRY, CDF glass-base metal-clad laminates of Teflon* and epoxy exhibit best dimensional stability and current-carrying capacity. Constant operating temperatures of 300°F — soldering temperatures to 500°F — are readily met by these specialized CDF Dilecto® laminates.

HIGH-HEAT FLEXIBLE INSULATIONS. CDF offers a wide choice of insulating tapes made of Teflon, silicone varnish, silicone rubber, and Micabond®, with glass-cloth support. CDF tapes may be used either by hand wrapping or on automatic winding machines. Unsupported Teflon in colors available to meet MIL-STD 104.

TEFLON SPAGHETTI TUBING AND OTHER SPECIALTIES. Part of CDF's vast fabrication facilities is devoted to the production of custom parts from Teflon — spaghetti tubing, rods, sheets, and machined parts to rigid specifications.

NEW — *cementable* Teflon, bondable to itself and to other materials with commercial adhesives.

SEE SWEET'S Product Design File, Electronics Buyers' Guide, and other directories for the name and phone number of your CDF sales engineer. Then send your print or your problem, and we'll return specific technical data and test samples.

*trademark of DuPont tetrafluoroethylene resin

CDF CONTINENTAL-DIAMOND FIBRE

A SUBSIDIARY OF THE Budd COMPANY • NEWARK 3, DEL.

FOR MORE INFORMATION CIRCLE 5 ON INQUIRY CARD

specify RAYTHEON for

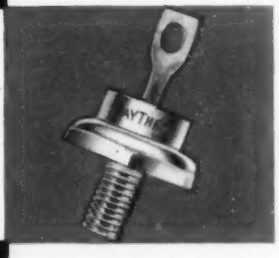
High Temperature, Applications

RAYTHEON PNP SILICON TRANSISTORS in the JETEC 30 package
made by the Raytheon-perfected Fusion-Alloy process for extreme reliability and long life. Lowest noise factor.
Temperatures from −65°C to +160°C.

RAYTHEON Guided Missile SUBMINIATURE TUBES with RELIABILITY +
more than meet military specifications for all characteristics important to guided missile and other critical applications.
Bulb temperature ratings to 265°C.

RAYTHEON Diffused Junction SILICON RECTIFIERS *Both Stud and Wire-In Types*
Ratings to 600 volts peak and 3.5 amperes
The Raytheon Solid State Diffused Junction process insures uniformity and exact control of characteristics.
Temperatures from −65°C to +165°C.

RAYTHEON SILICON POWER RECTIFIERS
Ratings to 325 volts peak and 15 amperes average with rectification efficiencies to over 99%.
Temperatures from −65°C to +165°C.



All illustrations are actual size

RAYTHEON Bonded SILICON DIODES
combine low reverse current, exceptional stability and uniformity with small size for a variety of applications requiring peak voltages to 300 and currents to 80 mA.
Temperatures from −65°C to +150°C.

For detailed specifications and application engineering information get in touch with our nearest office.

RAYTHEON ®

RAYTHEON MANUFACTURING CO.

SILICON AND GERMANIUM DIODES AND TRANSISTORS • SILICON RECTIFIERS
RELIABLE MINIATURE AND SUBMINIATURE TUBES • VOLTAGE REFERENCE TUBES
VOLTAGE REGULATOR TUBES • GAS FILLED TUBES • NUCLEONIC TUBES

NEWTON, MASS.: 55 Chapel St. • BIgelow 4-7500
NEW YORK: 589 Fifth Ave. • PLaza 9-3900
CHICAGO: 9501 Grand Ave., Franklin Park • TUxedo 9-5400
LOS ANGELES: 5236 Santa Monica Blvd. • NOrmandy 5-4221

FOR MORE INFORMATION CIRCLE 6 ON INQUIRY CARD

Here's Ho
Use HE

ABUSE

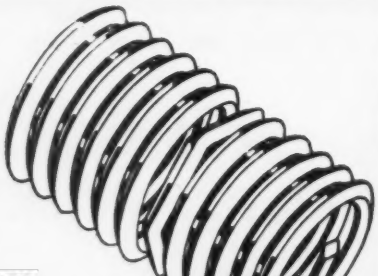
HELI-COIL Stainless Steel Screw-THREAD Insert

This is the insert that permanently protects threads against wear, stripping, corrosion, galling, seizing, vibration and shock. Made of (18-8) stainless steel wire, cold-rolled into a diamond shaped cross-section, this ***Heli-Coil*** Insert is work hardened to a tensile strength of approximately 200,000 psi . . . conforms to military standards MS 122076 through 122275 (ASG) and MS 124651 through 124850 (ASG) . . . conforms to standard commercial and industrial thread forms, including coarse, fine, pipe-thread and MM sizes . . . permits use of standard boss configurations.

Here Ar ome T

Save Space, Weight and Co
Substantial savings in materia proves desig weight, space and costs are possib tion of nuts, as against solid bushings, becau gth bolts. smaller (or standard) bosses, flang and threaded fasteners can be use

Comp



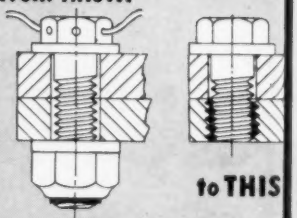
New HELI-COIL Stainless Steel Screw-LOCK Insert

Pat. Pending.

Conforming to military specifications for locking torque and vibration, this notable new ***Heli-Coil*** Screw-LOCK *one-piece* insert provides all the thread protection of the Screw-THREAD Insert, **PLUS** an exclusive internal locking feature that eliminates the need for clumsy protruding lock nuts, lock wiring and other supplementary locking devices . . . saves cost, space and weight . . . permits simplified streamlined design. The Insert is a permanently integrated part of the component—permits repeated service repair disassembly and reassembly, *with locking action remaining unimpaired.* Available in sizes from 4-40 up.

Here Ar ome Ty

from this...

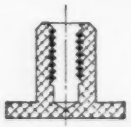


to THIS

Internal Locking Feature
Insures positive internal locking a tion—eliminates lock nuts, lock w ing and other protruding lockin devices—saves space, weight, co Yet screw may be easily disasse bled with no loss of locking torqu

Flush Nu
rmits a sec sembly, becau feature e lled head bo ding locking

➡ ***Heli-Coil* Field Engineers are at your service fesign co**



CUSTOM LOCK NUTS

The ***Heli-Coil*** Screw-LOCK Insert is adaptable to special-shaped lock nuts, shells, spacers and fasteners and can be engineered to meet your torque or performance requirements. ***Heli-Coil Corporation*** is fully equipped to manufacture these special lock nuts to your specifications.

Note: Custom nuts, with Screw-LOCK Inserts, meet military specifications for lock nuts.

ELI-C

A D

...s How Design Engineers ...se HELI-COIL* INSERTS to

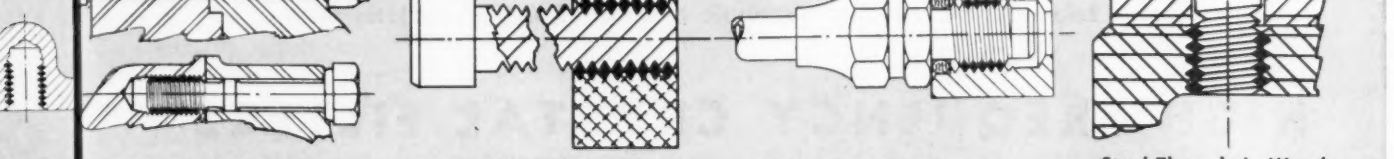
SAVE: SPACE—WEIGHT—COSTS

PERMANENTLY PROTECT THREADS AGAINST

...ABUSE • WEAR • CORROSION • STRIPPING • GALLING • SEIZING • VIBRATION

Eliminate Lock Nuts—Lock Wiring—Lock Washers

...e Ar...ome Typical *Heli-Coil* Screw-THREAD Applications



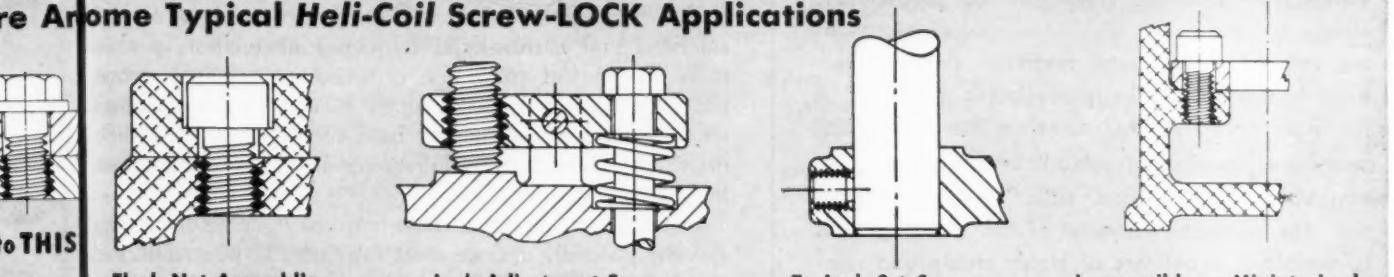
...and Cos... ...materia... ...proves design features by elimi... ...re possib...tion of nuts, washers and extra... ...gs, becau...ngth bolts. ...ses, flang... ...an be use...

Stronger Thread Connections
Under excessive tension, torsion and impact loads in standard proportion bosses, the screw will break but the *Heli-Coil* Screw-THREAD Insert will remain undamaged . . . even in light alloy metal.

Leak-Proof Connections
In lightweight, high pressure hydraulic equipment, stainless steel inserts, regular and pipe thread, protect threaded pump and valve ports sealed with "O" rings.

Steel Threads in Wood, Plastics and Fiberglas
Provides permanent, strong, corrosion-resistant and wearproof threads in soft materials. Especially valuable where frequent assembly and disassembly is necessary.

...re Ar...ome Typical *Heli-Coil* Screw-LOCK Applications



...o THIS

...eature
...locking ...
...s, lock w...
...ing locki...
...eight, co...
...y disasse...
...king torqu...

Flush Nut Assemblies
...mits a securely locked, flush ...embly, because its internal lock... feature eliminates need for ...lled head bolts and other pro... ...ding locking devices.

Lock Adjustment Screws
This simple design allows permanent, positive adjustment of screws in any position, secure against vibration or impact.

To Lock Set Screws
Positively locks assembly against loosening at desired adjustment—protects threads against stripping under high torque—permits use of light housing materials.

Inaccessible or Miniaturized Assemblies
Heli-Coil Screw-LOCK Insert permits installation of the locking feature from front or top. No blind fumbling for assembly of locking devices inside or behind.

...vice fesign consultation—without obligation.

...ELI-COIL CORPORATION

A Division of Topp Industries, Inc.

*Reg. U.S. Pat. Off.

HELI-COIL CORPORATION
2709 Shelter Rock Lane, Danbury, Conn.

Gentlemen: Please send me further information on

- ☐ *Heli-Coil* Screw-THREAD Inserts.
- ☐ *Heli-Coil* Screw-LOCK Inserts.
- ☐ *Heli-Coil* Custom Lock Nuts.
- ☐ Have a *Heli-Coil* Thread Engineer call—without obligation.

NAME_____ TITLE_____

FIRM_____

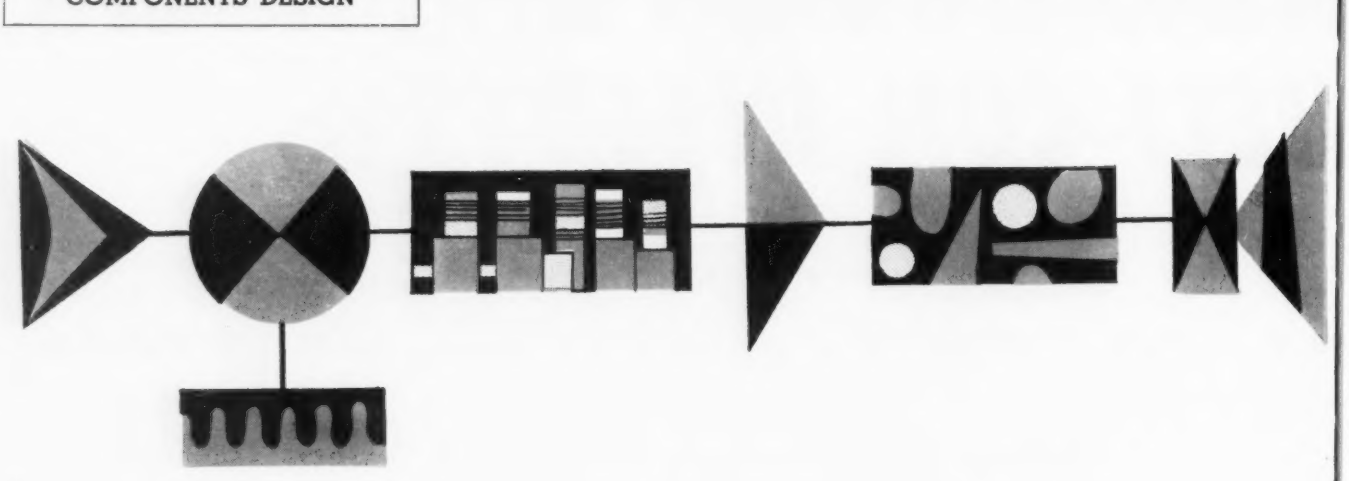
ADDRESS_____

CITY_____ ZONE_____ STATE_____

In Canada: W. R. WATKINS CO., Ltd., 41 Kipling Ave., S., Toronto 18, Ont.

FOR MORE INFORMATION CIRCLE 7 ON INQUIRY CARD

COMPONENTS DESIGN



New solutions for design problems in communication and navigation systems, Doppler radar, fire control systems, missile systems, carrier telephone systems, telemetering, spectrum analysis and data handling systems with

HIGH FREQUENCY CRYSTAL FILTERS

The crystal filter is a direct result of a unique marriage between the electrical and mechanical worlds. This union is known as the piezoelectric effect, by virtue of which mechanical vibrations are induced in a crystal resonator through electrical excitation. If the piezoelectric resonator is cut from crystalline quartz, then the mechanical resonances exhibit a remarkable freedom from environment effects and from frictional dissipation. The electrical analogue of this vibrating mass is, therefore, a network of highly stable and relatively lossless inductance and capacitance.

Working only with the electrical equivalent of the quartz crystal, the circuit designer may derive filter networks with characteristics which cannot be obtained by conventional techniques. However, the practical realization of these networks depends primarily on the ability to obtain crystal resonators with the required properties.

The development of a crystal filter is, therefore, accomplished by combining techniques of mechanical vibration analysis with those of electrical circuit analysis. The engineer involved in this process may be considered a charter member of the electromechanical design fraternity.

Information on which this article is based was supplied by personnel at M.I.T. and Hycon Eastern.

The past decade has brought about an enormous increase in the number of radio communication and navigation systems in operation. The resultant over-crowding of the radio-frequency spectrum has produced many equipment design problems. New systems, such as single-sideband and narrow-band frequency modulation, permit more economical utilization of existing frequency space but their success depends upon their ability to operate within a narrow well-defined band of frequencies. Accordingly, filter selectivity requirements have become increasingly stringent.

In addition, modern high-frequency communications systems generally operate most satisfactorily when filtering action is performed at as high a frequency as possible. However, at frequencies greater than a few megacycles, conventional types of filters with suitable characteristics are difficult to produce. Some designers have solved this problem with the use of successive frequency translations, commonly called multiple-frequency conversions, a process which reduces the frequency of the radio signal to the point where conventional filtering techniques can be used. The multiple-conversion process introduces increased circuit complexity with corresponding loss in efficiency and reliability.

The high-frequency crystal filter provides a new solution to these problems. Compact filter units employing miniature quartz-crystal resonators in the 5 to 40-Mc range provide filter performance previously possible only at significantly lower frequencies. Multiple-frequency conversions may thereby be eliminated, resulting in equipment simplification accompanied by improved performance and smaller size.

Desirable filter characteristics, such as high selectivity and low power loss, can be obtained in narrow-band, high-frequency filters only if the Q's of the filter components are extremely large. Quartz-crystal resonators normally employed in filter networks have Q's which range from 10,000 to 200,000 and have been produced with Q's in excess of 1,000,000. By comparison, the Q's normally obtainable in conventional inductances may range from 50 to 200, while the nickel-alloy resonators commonly employed in "mechanical" filters have Q's which range from 2,000 to 10,000.

The crystal filter is further characterized by a high order of stability over wide temperature excursions for long periods of time, and, in the presence of severe shock and vibration, does not exhibit microphonic behavior. These qualities are necessary if you are to take full advantage of the ability to produce narrow-band devices at high frequencies.

QUARTZ CRYSTAL RESONATORS

A quartz resonator is a small bar or plate cut from crystalline quartz. The crystal may have a number of vibrational modes in the vicinity of the desired response. However, by properly dimensioning the resonator and the electrodes which supply electrical excitation, you may produce crystals with essentially single-resonance characteristics at frequencies as high as 40 Mc. Dimensioning a crystal resonator so as to suppress undesirable modes of vibration and to produce a given temperature co-efficient generally results in the limitation of the equivalent electrical parameters to a narrow range of values. This limitation and the small zero-pole spacing of the crystal places theoretical and practical restrictions on the characteristics realizable with a given crystal filter configuration. These restrictions apply even to those networks in which inductances or resonant circuits are disposed in series or parallel with the crystal resonator in order to modify the resonator critical-frequency or zero-pole configuration.

The restrictions mentioned above make it desirable to utilize a design procedure which will rapidly and accurately indicate the range of filter characteristics obtainable with a given crystal resonator.

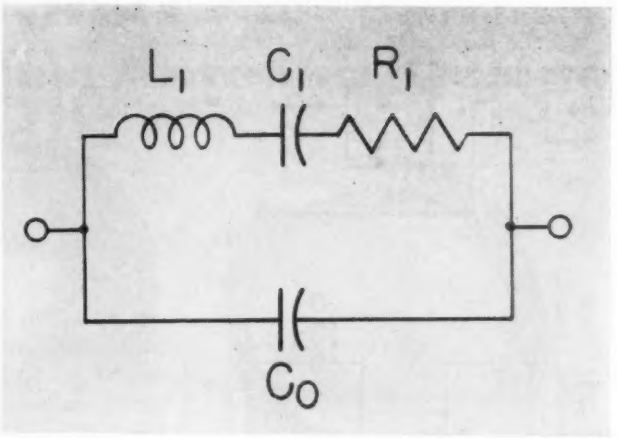


FIG. 1. In the vicinity of a resonant frequency, a quartz crystal may be represented by the equivalent electrical circuit above. The inductance L_1 and capacitance C_1 represent effective mass and stiffness of the crystal, respectively. C_0 is the static capacitance and includes stray-wiring and holder capacitance. Resistance R_1 represents frictional loss of the vibrating crystal. Crystal Q is defined as the ratio of reactance L_1 at resonant frequency to resistance R_1. Because of the extremely large value of Q, the crystal may be considered a purely reactive network for most filter applications.

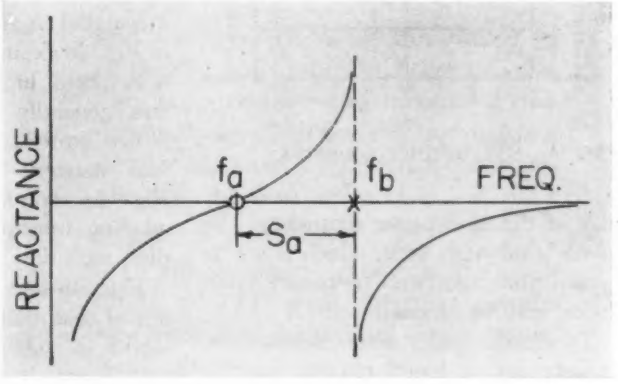


FIG. 2. Reactance curve above corresponds to lossless equivalent circuit of Fig. 1. Resonant frequency or "zero" of the crystal unit (f_a) and the anti-resonant frequency or "pole" (f_b) are very closely spaced. That is, S_a is a very small percentage of the crystal resonant frequency, at most, 0.2% of f_a for high-frequency crystals.

CRYSTAL FILTER CIRCUITRY

Almost all crystal filters of any significance produced in the past twenty years are based on the symmetrical-lattice or bridge networks developed by Warren P. Mason.

Several examples of lattice crystal filter circuits are in Fig. 3. Attenuation characteristics of these filters depend completely on the arrangement of critical frequencies or zeros and poles of the series (A) and shunt (B) arms of the lattice. Fig. 3a and 3b illustrate the crystal-capacitor lattices normally designated as narrow-band filters. The bandwidth of these filters is limited directly by the zero-pole spacings of the associated crystals. The upper bandwidth limit of the narrow-band, high-frequency crystal filter is about

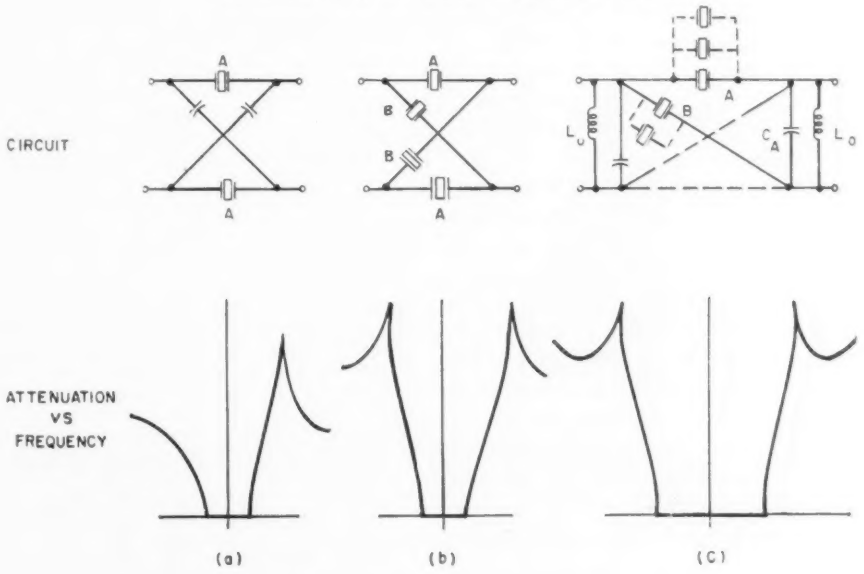


FIG. 3—Lattice crystal filters

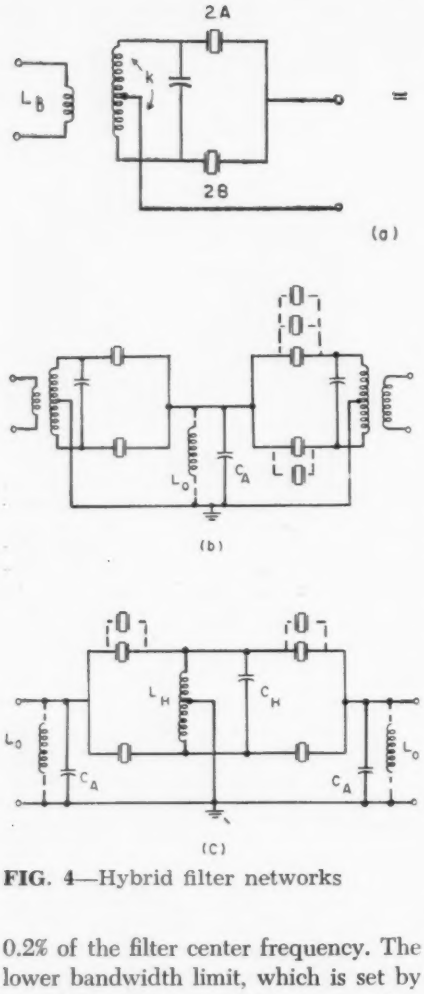
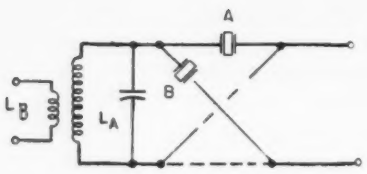


FIG. 4—Hybrid filter networks

0.2% of the filter center frequency. The lower bandwidth limit, which is set by crystal dissipation and frequency tolerances, may be as small as .01%.

To obtain wider filter bandwidths, inductances or tuned circuits may be placed in parallel with the lattice network as shown in Fig. 3c. The inductance L_O resonates in the vicinity of the filter center frequency with the crystal effective shunt capacitance $(C_O + C_A)$. A number of the resultant critical frequencies of the series and shunt lattice arms may be so arranged as to provide a narrow passband region. The width of this passband is not limited directly by the crystal zero-pole spacing. This type of filter, which will be called an intermediate-band crystal filter, may have somewhat wider bandwidths than the crystal-capacitor filter. An upper limit of about 0.6% is common in the high-frequency range.

The wide-band crystal filter results when all critical frequencies of an inductance-crystal combination are contained within the filter bandwidth limits. Bandwidth range for this filter type is about 1.5% to 6% of the filter center frequency. The upper limit is set by the crystals, the lower by the Q's realizable for L_O.



Dissipation or midband insertion loss introduced by the filter network is only 1 or 2 db for most narrow- and intermediate-band filters. For the wide-band filters, the corresponding loss is dependent on filter bandwidth and external inductance Q. For a 5% filter bandwidth and a Q of 100, filter loss will be approximately 6 db.

The simple filters of Fig. 3 form basic building blocks for more complicated filter networks. Greater attenuation and selectivity may be obtained either by cascading sections of the type shown or by placing several crystals in parallel in any lattice arm as shown in Fig. 3c (connections shown dotted).

Practical high-frequency crystal filters generally utilize an unbalanced lattice equivalent known as the "hybrid" network. This network, shown in Fig. 4a, employs a balanced three-winding transformer with closely coupled secondary windings k = 1).

Figs. 4b and 4c illustrate two methods of cascading hybrid-type filter networks to achieve greater attenuation and selectivity. Any combination of Figs. 4a, b and c may be employed to provide still better performance. Alternatively, crystals placed in parallel (shown dotted) in any lattice arm will accomplish the same result. The inductances L_O may be added to convert the network from the crystal-capacitor lattice (Fig. 3b) to the intermediate-band or wide-band lattice (Fig. 3c). In addition the parallel circuit $L_O - C_A$ in Fig. 4c provides a convenient means of altering the nominal impedance level of the filter. The desired impedance transformation is simply accomplished by tapping L_O or C_A for the appropriate impedance level. In this manner, the same filter may be used with high-impedance vacuum-tube circuitry or low-impedance transistor circuitry.

Utilizing the hybrid filter networks illustrated in Fig. 4, crystal filters have been produced through the frequency range of 10 Kc to 40Mc, with bandwidths ranging from 1 cycle per second to several hundred kilocycles per second. The corresponding range of percentage bandwidths is 0.1% to 7% of center frequency.

Lattice-type crystal filter networks may be designed by utilizing classical image-parameter synthesis techniques or by considering the total insertion loss of a given filter network. However the values of the equivalent electrical parameters of the crystal resonator are not completely within the filter designer's control. Because the crystal filter is normally restricted to bandwidths which are a very small percentage of the center frequency, and because of the nature of the equations involved in the image-parameter synthesis of these filters, it is possible to develop a procedure which permits the

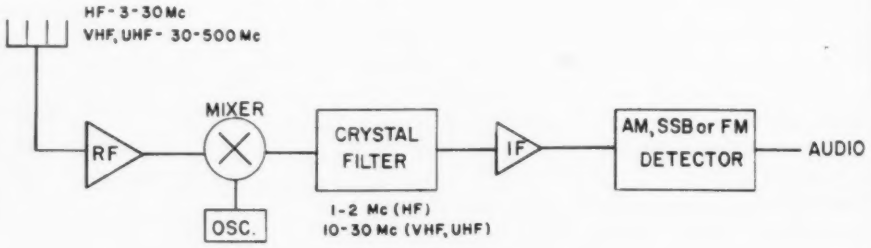


FIG. 5—A high frequency crystal filter permits a communications receiver operating from HF through UHF to be no more complicated, in principle, than the conventional broadcast superheterodyne receiver. The single-conversion crystal-filter receiver has the advantage of a high frequency first I-F (i. e. good image rejection), combined with high adjacent channel selectivity (previously achieved only through multiple frequency conversion). At the same time, the elimination of multiple conversions reduces cross modulation and receiver desensitization due to mixer overload, and locally generated spurious signals. Since the frequency selection characteristics of the entire receiver are determined primarily by the crystal filter unit, it's possible to alter the receiver bandwidth and selectivity characteristics by simply changing the filter. Crystal filters designed for single conversion receivers have been produced with bandwidths ranging from 250 cps (for HF-CW telegraphy) to 50 kilocycles (for VHF-FM or UHF-AM).

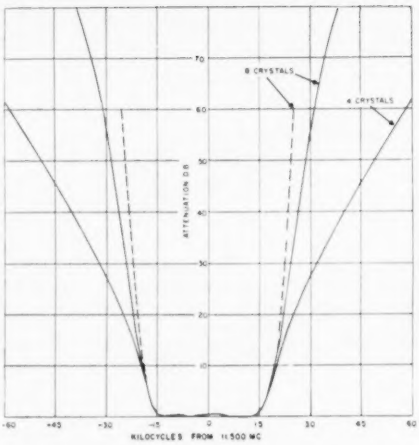


FIG. 6—Attenuation characteristics of filter at 11.5 Mc designed for VHF-FM receivers show the comparison between a four-crystal filter with a shape factor approximately 3.5:1 and an eight-crystal filter with a shape factor approximately 1.7:1. Shape factor is the ratio of the bandwidth at 60-db attenuation to the bandwidth at 6-db attenuation. The eight-crystal device may be made considerably more selective (i.e. smaller shape factor) at the sacrifice of the final or "ultimate" attenuation reached by the filter. For example, the dotted characteristic (shape factor 1.3:1) may be obtained by permitting the filter to return to an attenuation of slightly greater than 60 db. Solid eight-crystal characteristic reaches an attenuation well over 80 db and represents a good compromise between final attenuation and shape factor for this application. The 6-db bandwidth for the filters above is approximately 35 Kc. For the new split-channel FM operation, filters with identical characteristics have been produced with bandwidths of 15 Kc.

design of even the more complicated crystal filters utilizing only simple calculations and graphical aids. This procedure, based on a normalization or approximation technique, provides solutions with accuracies that are normally well within the tolerances placed on filter components. A complete and detailed description of this synthesis procedure may be found in Technical Report 298, Research Laboratory of Electronics, M.I.T.

APPLICATIONS AND TYPICAL CHARACTERISTICS

The bandwidth range from one or two cycles to several hundred kilocycles per second, which represents the present day boundary of crystal filter technique, encompasses the majority of channel or information bands allocated to communications and navigation equipments. The ability to produce a given bandwidth at substantially higher frequencies, together with the excellent selectivity, stability, and loss characteristics of the high-fre-

Square-Hole Ball Bearing Simplifies Antenna Design

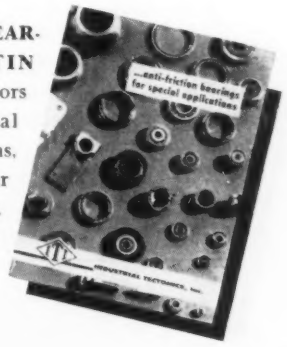
This radar bearing, 1.500" OD, carries 3000 lb. thrust while turning through 180° at 90 oscillations per minute. The split outer race permits larger ball complement and increased load capacity.

In planning the mechanical design of a radar antenna, the designer found that by using a ball bearing with a square hole, he could avoid limitations imposed by standard bearings. To bring this dream to reality, he had Industrial Tectonics design and produce the special bearing shown above. This has resulted in (1) a simpler and less costly design of the assembly that the bearing carries, and (2) a stronger and more rigid support.

In this and many other ways, the availability of ITI special bearings permits new freedom of design, and new economy. Remember –

IF YOU need anti-friction bearings of *special shape, size, heat resistance, corrosion resistance, low torque, ultra precision, non-magnetic properties, or other unusual characteristics,* we can supply them – designed and built to your specific requirements. We invite your inquiries.

FREE 32-PAGE BEARINGS BULLETIN tells about the factors involved in special bearing applications, and describes our work in this field. *Write for Bulletin AFB-1.*



INDUSTRIAL TECTONICS, Inc.

ITI

MANUFACTURERS OF PRECISION BALLS AND BEARINGS

3666 JACKSON RD., ANN ARBOR, MICH.

WESTERN DIVISION PLANT: COMPTON, CALIFORNIA

FOR MORE INFORMATION CIRCLE 8 ON INQUIRY CARD

ROBOTESTER

The easiest way to automation

ro'bo-tes'ter. An electronic device which will perform a series of circuit checks on an assembled chassis, automatically indicating failures due to shorts, opens, or out of tolerance parts, etc. Uses punched tape to set up tests.

ROBOTESTER offers a technique of automatic testing for the small run as well as the high-production system. The unique punched-tape programming permits fast set-up, fast change-over, fast correction. No bulky jigs or test units... the entire test program for a complete system can be stored in your pocket! ROBOTESTER has reduced test time for its users to 20% of manual testing, and without weeks of jig-building. Write for complete information and circuit description.

SPECIFICATIONS

Measurement: DC resistance

Range: 1 ohm to 10 megohms

Tolerance: 5, 10, or 20%

Sequence: Any. Tests in random order, above or at ground

No. of measurements: Between any 2 of 240 points

Programming: By punched paper tape

Tape preparation: By user; punch supplied

Speed: 100 tests per min., max. average 60-90

Tape life: Over 25,000 cycles

Maintenance: Plug-in subassemblies

Specialized automatic test equipment and calibration equipment is also available from Lavoie Laboratories. Write us.

Lavoie Laboratories, Inc.

Matawan-Freehola Road
Morganville 18, N.J.
MAtawan 1-2600

CIRCLE 9 ON INQUIRY CARD

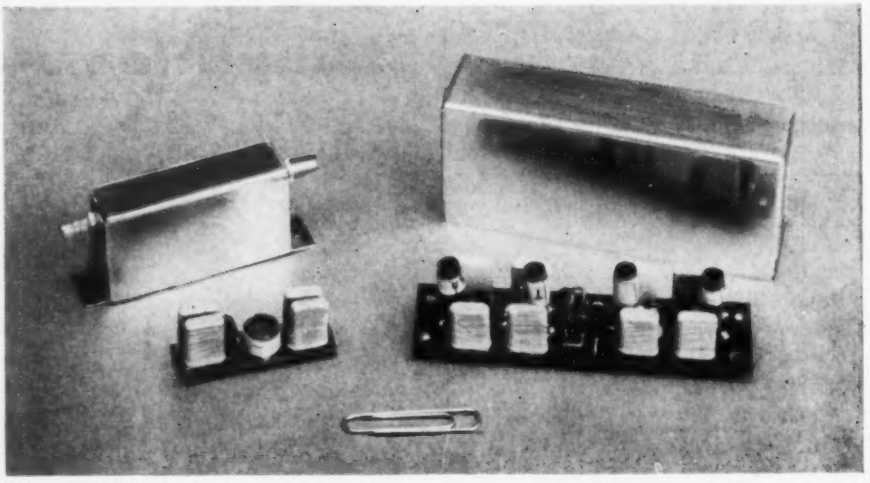
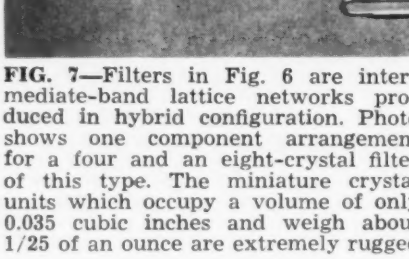
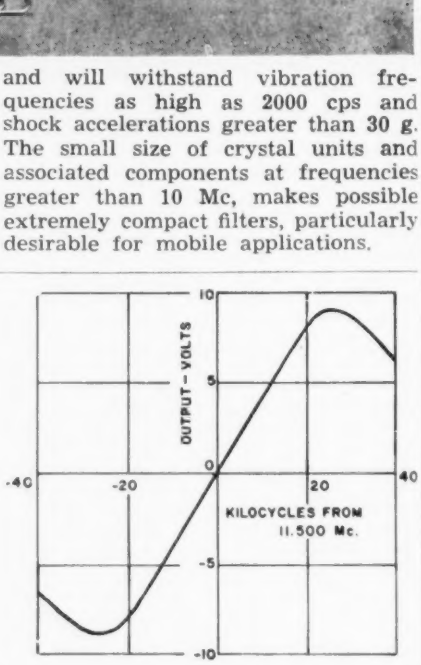


FIG. 7—Filters in Fig. 6 are intermediate-band lattice networks produced in hybrid configuration. Photo shows one component arrangement for a four and an eight-crystal filter of this type. The miniature crystal units which occupy a volume of only 0.035 cubic inches and weigh about 1/25 of an ounce are extremely rugged and will withstand vibration frequencies as high as 2000 cps and shock accelerations greater than 30 g. The small size of crystal units and associated components at frequencies greater than 10 Mc, makes possible extremely compact filters, particularly desirable for mobile applications.



(a)



(b)

FIG. 8—To utilize the single conversion technique in FM receivers, detection must be performed at the first I-F. Since the first intermediate frequency may be too high to permit the realization of a conventional type of FM detector or discriminator, a crystal discriminator has been developed which possesses a stability comparable to that of the high frequency crystal filter and which operates at the filter frequency. This device may be applied not only to FM receivers, but also to automatic frequency control systems and frequency modulation generators. In the basic circuit diagram of the crystal discriminator above, the voltage developed across each element in the series crystal capacitor combination X-C_2 is rectified by the diodes, D_1 D_2. The difference between these voltages is developed across the combination R_1—R_2, producing the required characteristic. The discriminator above is designed for use in conjunction with the filters of Fig. 6. It has a center frequency of 11.5 Mc and a peak-to-peak bandwidth of approximately 50 Kc. When driven from a conventional pentode limiter, which operates at a peak RF input voltage of 2 volts, the discriminator output voltage is approximately 16 volts peak-to-peak.

quency crystal filter, has already resulted in many applications of this new component.

The crystal filter is widely applied to intermediate frequency filtering applications in AM, SSB, and FM receivers, and single-sideband generators. For mobile versions of these systems, filters from 10 to 30 Mc are particularly attractive. In addition to their excellent performance characteristics, these devices offer the advantages of small size (½—2 cubic inches) and freedom from microphonic behavior.

Many applications require equipment which operates on a fixed channel or small number of channels at some frequency below 30Mc. You may convert a conventional receiver to a fixed-channel receiver by inserting a crystal filter between the antenna and the first R-F stage. In the presence of strong adjacent-channel interference in the HF bands, this technique materially reduces interference caused by intermodulation and desensitization. The excellent temperature stability of the crystal filter, combined with the close

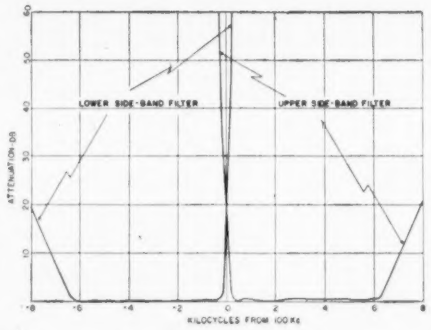


FIG. 9—In the generation of single side-band signals by filtering techniques, signal quality is largely dependent upon the ability of a filter to pass with negligible distortion one sideband of an amplitude modulated signal and simultaneously to effectively eliminate the other sideband. The high Q of the crystal resonator, and the ability to produce filters with assymmetrical attenuation characteristics (i.e. attenuation rising more steeply on one side of the passband than on the other), makes the crystal filter particularly well suited to single-sideband generation. The plot above shows attenuation characteristics of two filters designed for single-sideband generation at a frequency of 2000 Kc. Each filter has a bandwidth (at 2 db) of over 6 Kc, and an attenuation slope which rises from 2 db to 60 db in less than 600 cps. Intermediate-band hybrid circuitry is employed resulting in insertion losses of less than 3 db. Crystal filters for SSB generation have been produced at frequencies as low as 80 Kc and as high as 16 Mc.

tolerances which can be maintained on the shape of the filter characteristic (crystal frequency tolerances of ±.001% or less are common for oscillator and filter applications), makes the crystal filter particularly well suited for frequency channelizing or "comb" filter applications. Filter sets of this type, containing as many as five hundred filters per set, have been produced at frequencies as low as 100Kc and as high as 28 Mc, for application to telephone systems, Doppler radar and fire control systems, and spectrum analysis.

Further progress in the development of quartz resonators may make possible the extension of the filter frequency range to frequencies approaching 100 Megacycles. Filter bandwidths in the order of 1-5 Mc may be achieved, permitting the application of crystal filters to wide-band systems such as pulsed radar and television. Finally, the perfection of new piezoelectric and ferroelectric materials such as the Titanate ceramics would provide an additional avenue toward the realization of other useful crystal-filter characteristics.

how to put more profit into your product ...in your design

Engineering projects can be completed quicker . . . Laboratory and production operations speeded up . . . Greater profits retained . . .

BECAUSE

PANORAMIC'S NEW SONIC ANALYZER LP-1a

Used in designing, improving and production testing:

Ball bearings
Jet and reciprocating engines
Electric motors
Home appliances
Business machines
Pumps
Blowers and fans
Compressors
Air frames
Tire performance
Any rotating or oscillating machinery

provides high-speed visual analysis of sounds, vibrations and electrical waveforms . . . identifies mechanical and electrical defects or variations.

Versatile, flexible, fast. In only one second the LP-1a depicts the frequencies and amplitudes of sound or vibration waveform components, eliminating tedious, complicated point by point measurements. Makes possible observation of changes in energy distribution while the waveform itself varies or while design constants are altered.

Data presented graphically for direct reading. Optional companion recorder permits permanent recordings of waveform content over extended periods. Tuning control and three-step scanning range allow sharp, detailed analysis. A valuable aid designwise or productionwise.

the pioneer is the leader

PANORAMIC
RADIO PRODUCTS, INC.

Get complete details on how a Panoramic Sonic Analyzer can help you.

Descriptive data sheets, prices, delivery schedules sent on request. A Panoramic Application Engineer will be glad to discuss your Spectrum Analysis problems with you. Special instruments to order.

522 South Fulton Avenue, Mount Vernon, New York • Phone: OWens 9-4600

Cables: Panoramic, Mt. Vernon, New York State

These organizations have found Panoramic equipment PROVED PERFORMERS:—Allis-Chalmers Mfg. Co., Bell Aircraft Corp., Bell Telephone Co., Boeing Airplane Co., California Institute of Technology, Chrysler Corp., Convair, Cornell University, Curtiss Wright, Dept. of Defense, E. I. Dupont de Nemours & Co., Eastman Kodak Co., Ford Motor Co., General Electric Co., General Motors Corp., Hot Point Co., Lockheed Aircraft Corp., Massachusetts Institute of Technology, Philco Co., Pratt & Whitney Aircraft, Radio Corporation of America, Sperry-Gyroscope Co., U. S. Testing Co., Inc., Western Electric.

FOR MORE INFORMATION CIRCLE 10 ON INQUIRY CARD

ELAPSED TIME INDICATOR

Ingenuity in Design

Small size, light weight designs frequently present production problems once the design challenge has been met. Such was the case confronting the Magnetic Instrument Manufacturing Corporation, Thornwood, New York, in the design of an elapsed time indicator for airborne electronic equipment.

Design objectives included a time range from zero to 10,000 hours, accuracy in the order of a few percent, volume somewhere around 3½ cubic inches and weight about four ounces hermetically sealed and with a production price of $40/$50 in quantities.

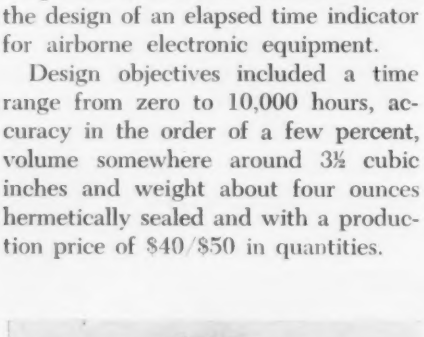


FIG. 1—Hermetically sealed elapsed time indicator weighs four ounces and measures 1¼" x 1¼" x 2¼". Time range is 9,999.9 hours indicated on five counter wheels.

Magnetic Instrument's engineers started with a more or less standard approach calling for a synchronous motor, the speed of which is determined by the line frequency, and a gear train driving a digital counter. This immediately presented a problem because a standard 400 cycle four pole synchronous motor runs at 12,000 rpm. They felt that almost anything running at 12,000 rpm would have a life expectancy considerably lower than 10,000 hours. This portion of the problem was solved with the design of a small low speed motor, running synchronously at 2400 rpm. With the motor design out of the way, Magnetic's engineers turned to the problem of a gear train with a 144,000 to 1 reduction in the extremely small size available.

First, instead of using four counters for a 10,000 hour count, they used five to reduce the gear reduction by a factor of ten which also permits time to be read in decimal fractions of an hour. At this point the gear reduction problem was now 14,400 to 1, the square root of which is 120, requiring two gear passes of 120 to 1 each. Solutions involving other choices of ratio were considered but there are obvious advantages in this arrangement as the gears are identical and therefore interchangeable.

Worm gearing was the obvious solution but as other design requirements limited the gear centers to the order of one half inch no commercial gears

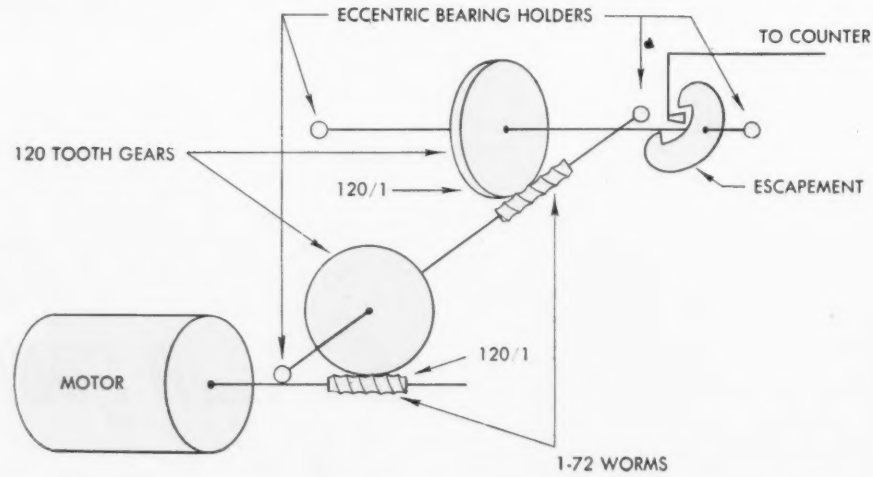


FIG. 2—Above gear train shows how reduction of 144,000 to one was accomplished with two worms, two 120 tooth gears and an escapement. Because the counter is a ratchet operated unit, the escapement gives the required additional 10:1 reduction.

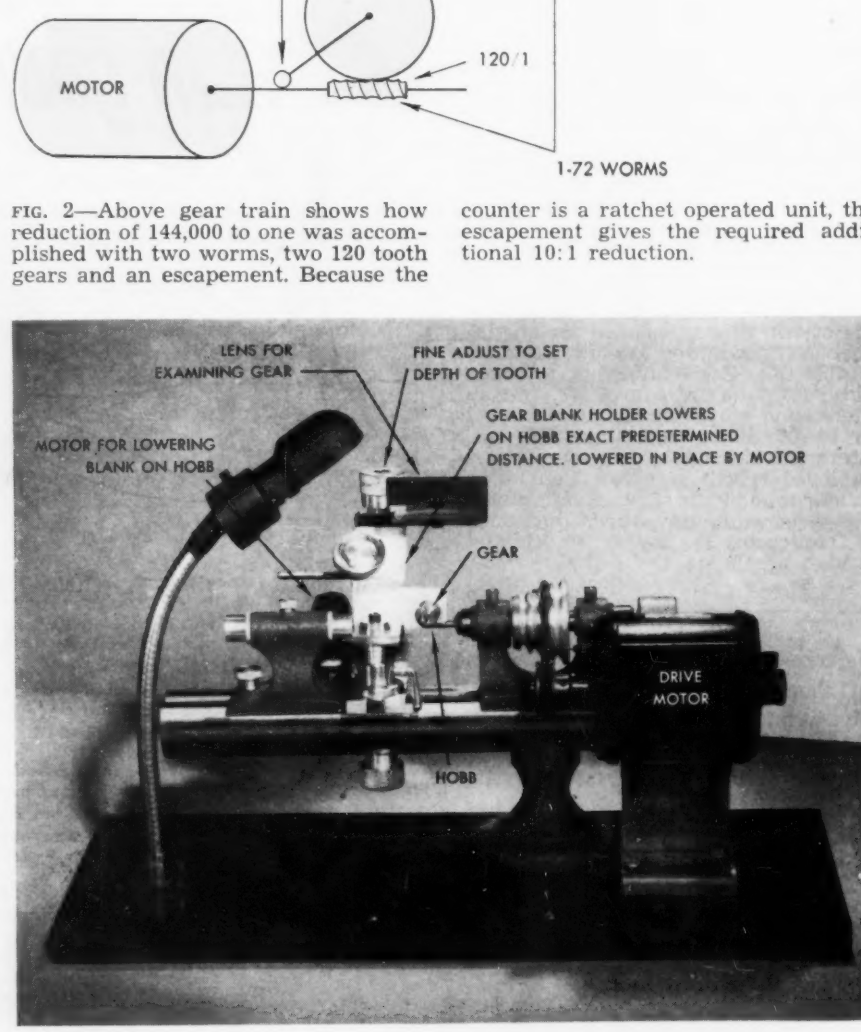

LENS FOR EXAMINING GEAR
FINE ADJUST TO SET DEPTH OF TOOTH
GEAR BLANK HOLDER LOWERS ON HOBB EXACT PREDETERMINED DISTANCE. LOWERED IN PLACE BY MOTOR
MOTOR FOR LOWERING BLANK ON HOBB
GEAR
DRIVE MOTOR
HOBB

FIG. 3—When no source of supply for their gear requirements was readily available, Magnetic Instrument Manufacturing Corporation's engineers made an automatic gear shaper from a watchmaker's lathe. The operator places the gear blank on the shaft, pushes a button and the machine automatically lowers the blank on the hobb a predetermined distance to establish tooth depth and cuts the gear. When the gear is cut the machine automatically stops, the operator removes the gear and inserts a new blank. Operation now takes about two minutes. Time can be considerably reduced should the need for extra capacity arise.

were readily available. Faced with this problem it was decided to make special gears within the Company and a machine was designed for this (Fig 3).

The machine is designed around a standard watchmakers lathe and is virtually automatic. The operator places an accurately machined gear blank on the shaft and presses a button. The machine then feeds a hobbing cutter into the blank to a predetermined depth after which the cutter retracts and at the conclusion of the cycle the machine shuts off. The operator then removes the finished gear, inserts a new blank and the cycle is repeated. The operation now takes two minutes but the time can be considerably reduced should the need for extra capacity arise.

After cutting, the gear is examined in an optical comparator with a magnification of fifteen diameters.

In view of the very small tooth depth and consequent minute clearances implicit in this design the bearings supporting the two gear passes were designed as eccentrics so that proper spacing could be achieved with a simple adjustment (Fig 2). Total "play" in the design is approximately 0.002".

Interesting design detail: Because the severe space requirements did not allow for a shoulder on the motor for attachment to the back plate, it was recessed and the motor pressed in, the assembly being finally cemented with an epoxy resin as an additional safeguard. This procedure gave a bond which satisfied the design requirements so the unit would withstand the relevant military vibration specification.

WORTH FILING

Hydraulic Control Valves

Six catalogue sheets describing new hydraulic directional control valves for earth moving, material handling, agricultural and other mobile equipment. Valves are engineered with exceptionally low pressure drop to provide metering characteristics in raising, positioning, rotating, holding or lowering operations. Open center parallel circuit design permits independent or simultaneous operation of two or more cylinders or hydraulic motors at one time at pressures up to 2000 psi.

Issued by: Industrial Hydraulics Division, Parker Appliance Company, Cleveland, Ohio

For your copy: Circle 141 on Inquiry Card

from STOCK
...or from your SPECS
COSMO Nylon Bobbins
Cosmo molding methods produce nylon bobbins and washers to your exact specifications or you can order from a wide variety of shapes and sizes carried in stock for immediate shipment.
Among the many features found in Cosmo "zytel" Nylon Bobbins are: • Strength in thin sections • Dimensional stability • Secure flanges (one solid molding) • Resistance to impact • Resistance to action of many common chemicals • Rated for use up to 250°F • Good dielectric strength.
Investigate the benefits—savings . . . increased production speed . . . elimination of rejects with Cosmo Nylon Bobbins.
We Welcome Your Inquiry.
New catalog and samples on request.
SALES DIVISION OFFICES
Arizona, Missouri, Illinois, Michigan, Ohio, New Jersey, Connecticut, Massachusetts, Canada
COSMO PLASTICS COMPANY
3239 WEST 14 STREET • TOWER 1-5597 • CLEVELAND 9, OHIO
CIRCLE 12 ON INQUIRY CARD

A Book You Should Have on Mechanical Sealing...

A complete reference catalog on Dura Seal—the engineered mechanical seal that rotates with the shaft. Amply illustrated . . . specific applications . . . installation data. A fact book of real value to designers, operators and maintenance departments.

WRITE FOR DURA SEAL CATALOG NO. 455 EL

DURAMETALLIC CORPORATION

KALAMAZOO, MICHIGAN

CIRCLE 13 ON INQUIRY CARD

Now-
A FULL LINE OF
Luster-on® POWDERS
FOR CHROMATE TREATING

ZINC

#50: Bright, clear, lustrous, nickel-like, corrosion-resistant; requires leach.
#51: Similar to #50, but bluish chrome-like color.
#52: Low-cost, no leach, bright, passive.

CADMIUM

#50: See under Zinc, above.
#53: Improved solubility, control, safety in handling; requires leach.

COPPER & BRASS

Cobra: Bright, yellowish, decorative and/or protective film, non-fuming, single dip.

ALUMINUM

222M Sealer: Clear or colored film for corrosion protection and paint bond.

MAGNESIUM

MPD 60: Yellowish film for corrosion protection and paint base.

Data Sheets and Prices on Request.
Send in part for free processing.

West Coast: Crown Chem. & Engr. Los Angeles & San Francisco
Canadian Licensee: Alloycraft Ltd. Montreal

THE Chemical CORPORATION
74 WALTHAM AVE., SPRINGFIELD 9, MASS.

CIRCLE 15 ON INQUIRY CARD

COMPONENTS DESIGN

SHAPED-BEAM TUBE

Time Sharing Design

A "Charactron" shaped-beam tube, small enough for aircraft use, reproduces a conventional radar display map and then prints labels on it by means of time sharing. Characters are printed on the phosphor screen at the rate of 20,000 a second and retained by the phosphor while the electronic device does its radar work.

A wide electron beam floods a matrix containing stencils of all desired letters and numbers. This beam then is shaped by the stencils in the form of the characters in the matrix. The bundle of characters thus formed is focused on a tiny aperture that allows only one character at a time to pass. The beam's direction is changed to select each desired letter or number.

Internal electrostatic lenses accomplish focusing eliminating external focus and convergence coils. Comparative shortness of the electron gun allows use of fewer electrodes.

The tube was developed by Stromberg-Carlson Division of General Dynamics Corporation, San Diego, Calif.

Circle 235 on Inquiry Card

CERAMIC RELAY

Redundance for Reliability

A relay that operates satisfactorily during vibration of 25G from 10 to 2000 cps, during 50G shock and at ambient temperatures of 200° without contact chatter was introduced at WESCON. Contacts of the new relay are in a vacuum surrounded by a sturdy stacked ceramic enclosure.

The unit uses three contacts in parallel in each switching circuit to obtain high reliability, high current handling capacity and to eliminate contact bounce effects. These relays will switch low level "dry" circuits in the millivolt-microampere range as well as handle inductive loads with peak inrush currents of 60 amperes. Continuous rating of the contacts is 25 amperes at 300 volts.

Use of a vacuum minimizes sparking and pitting. High temperature processing required during manufacture results in volatilizing of foreign materials which might otherwise cause contamination of the contacts.

Jennings Radio Manufacturing Corporation is currently developing larger ceramic relays for handling inrush currents up to 1500 amperes, as required in missiles applications.

Circle 240 on Inquiry Card

PHASE GENERATOR

Dial for Time Phase

Simple, accurate phase shifting is obtainable with a new electromechanical device containing no tubes, transistors or magamps. When excited with a fixed voltage at a fixed frequency, it produces a constant output voltage of the same frequency whose time phase can be continuously controlled by a dial assembly (Fig. 1). Two such outputs are available which instantaneously differ from each other by 90-degrees in time phase.

Theta Instrument Corporation of East Paterson, N. J. says the advantages of its new unit over purely electronic phase generators are:

- Absence of tubes and associated power supplies allows more compact and more reliable design.
- Warm-up time is not necessary.
- Less adjustments prior to use.

Its disadvantage, they say, is that it requires a fixed carrier frequency.

The electrical portion of the electromechanical phase generator consists of resistors, capacitors and a precision resolver (Fig. 2). The network operates upon the input voltage, breaking it into two components equal in amplitude, but different in time-phase by 90 degrees. Each component is inserted into

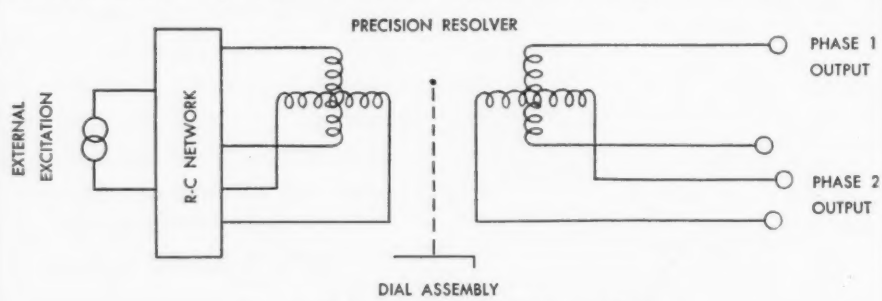


FIG. 2—Schematic of phase generator.

Section of department making stators for Bendix synchros and motors

SHOP AT THE BENDIX "SUPERMARKET" TO TAKE ADVANTAGE OF MASS SYNCHRO PRODUCTION FACILITIES

Fast delivery of practically any type synchro at minimum cost. Isn't that what you want from your synchro supplier?

If so, consider how well Bendix fills the bill. First, as a virtual "supermarket" for synchros, we maintain mass production that means minimum unit prices, even to small-quantity buyers. Second, we produce virtually all types of synchros as *standard items,* meaning you can get delivery fast *—immediately,* in most cases.

Finally, Bendix synchros are built to exacting precision standards that equal . . . or exceed . . . those of any other synchros made.

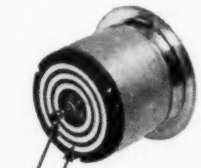
Let our vast experience and mass production facilities go to work on *your* synchro needs, too!

District Offices: Burbank, Calif., Dayton, Ohio, Seattle, Wash. Export Sales and Service: Bendix International Division, 205 E. 42nd St., New York 17, N. Y

EXTERNAL SLIP RING AUTOSYNS®

Bendix external slip rings replace ordinary fixed leads where it is desired to rotate the stator in addition to, or instead of, the rotor. Individual mechanical and electrical requirements determine location and configuration of these external rings.

As can be seen from the few examples below, many variations are possible in Bendix External Slip Ring Autosyns.



Three external stator rings in face of Autosyn.

Two external rotor rings.

Rotor and stator rings mounted concentrically with outside diameter of housing.

Rotatable gear mounted to Autosyn.

Rotor and stator take-offs are by means of brushes riding on these external rings.

Eclipse-Pioneer Division

Teterboro, N. J.

Bendix AVIATION CORPORATION

FOR MORE INFORMATION CIRCLE 14 ON INQUIRY CARD

Design Electronic Controls for RELIABILITY IN SERVICE with Alden Components for PLUG-IN UNIT CONSTRUCTION

Be sure your Engineers are working with the Alden Handbook of plug-in unit design. Presents complete line of basic components of tremendous flexibility for adapting your equipment to plug-in construction.

REQUEST FREE 250-PAGE "ALDEN HANDBOOK"

1. *Unitize your circuitry in compact vertical planes using Alden Terminal Card Mounting System.*

PREPUNCHED TERMINAL MTG. CARD
MINIATURE TERMINALS
JUMPER STRIP Eliminates wiring for common circuits
CARD-MTG. SOCKETS
YOUR COMPLETED CIRCUITS FOR PLUG-IN PACKAGE OR CHASSIS

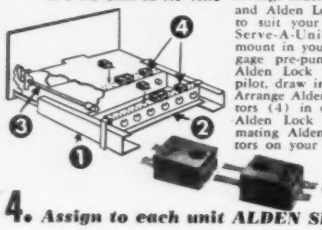
You can use Alden Terminal Mounting Card with Alden Miniature Terminals, Jumper Strip and Sockets staked to accommodate any circuitry — making complete units ready for housing. Components snap into unique Alden Terminals, are held ready for soldering.

2. To mount this vertical circuitry, ALDEN PLUG-IN PACKAGES AND CHASSIS give tremendous variety with standard components

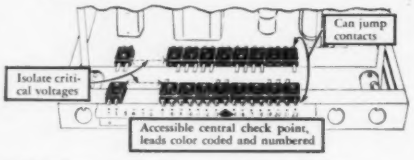
Alden components provide standard plug-in or slide-in housings—with spares, your circuits become units replaceable in 30 seconds.

3. Give chassis easily traceable interconnects and 30-second replacement with ALDEN SERVE-A-UNIT KIT

IT'S AS SIMPLE AS THIS Arrange Alden Side Rails (1) and Alden Lock Frame (2) to suit your chassis. Alden Serve-A-Unit Locks (3) mount in your chassis to engage pre-punched holes in Alden Lock Frame (2) to pilot, draw in, lock or eject. Arrange Alden Back Connectors (4) in orderly row on Alden Lock Frame. Mount mating Alden Back Connectors on your Chassis.



GIVING YOU 1) Chassis that plugs in, locks and ejects with half turn of the wrist. 2) leads so beautifully organized, accessible and identified that non-technical personnel can service.



4. *Assign to each unit ALDEN SENSING ELEMENTS — to spot trouble instantly:*

9138 N. Main St., Brockton 64, Mass.

ALDEN PRODUCTS CO.

From Alden's Line of Ready-made Components for Unitized Plug-in Unit Construction.

WE MOLD AND FABRICATE RUBBER AND SYNTHETICS WITH IMAGINATION

Difficult . . . Intricate. These perfectly executed BELLOWS

represent the care and skill of master craftsmen . . . years of experience and know-how.
Made in many sizes . . . many shapes . . . bellows such as these are key links in thousands of different types of equipment . . . perform important functions.
For the important functioning of your product or equipment . . . for that key link . . . whether it be a simple channel, bumper, or weather strip; seal, washer or grommet; diaphragm or connector . . . we can help solve your problems in designing, molding or fabricating mechanical goods of rubber and synthetics.
Write, wire, phone for more complete information, TODAY. If you have prints, ask for quotation.

MECHANICAL RUBBER PRODUCTS CO.
America's Newest and Most Modern Rubber Works

21 Vail Road • Warwick, New York • WArwick 55-2271
Direct N.Y.C. Phone: REctor 2-9652 • Representatives in leading cities

CIRCLE 16 TOP, 17 BOTTOM ON INQUIRY CARD

a separate resolver winding. The resolver is basically a variable transformer which at one point is fully coupled to the zero-degree component and ninety space-degrees away is fully coupled to the 90-degree component. Thus the resolver makes possible the conversion of "time-phase" to "space-phase."

DESIGN PROBLEMS

Theta engineers' major design problem was in creating an output that would maintain its phase accuracy through a wide range of output impedances and input voltages. Both the resolver and network characteristics are normally altered in the face of these two variables.

One problem was solved by selecting precision resolvers under simulated load conditions to insure the maintenance of phase accuracy in application.

The other problem was solved by taking advantage of the transformer characteristics of the resolver to impedance isolate the passive network from the output load.

Major manufacturing problem, according to Theta engineers, was one of maintaining accuracy without excessive cost. They decided to divide the instruments into three categories with phase accuracies of 12 minutes, 30 minutes, and two degrees. Each resolver is tested for electrical error by the four-arm bridge method and classified into the three groups. Each passive network is tested for amplitude balance and 90-degree phase shift and also placed into three groups. In this manner, virtually all component parts can be grouped into one of the three accuracy classes.

FREQUENCY CHARACTERISTICS

Since the phase generator is sensitive to frequency, a circuit trimmer compensates for a ten percent deviation from the nominal excitation frequency. At the factory, each unit is set for an excitation frequency within 0.2 percent of nominal. The excitation source should have a frequency stability consistent with the phase accuracy the application demands.

AMPLITUDE CHARACTERISTICS

As the dial of the phase generator is rotated through 360 degrees, the output amplitude is factory adjusted to vary less than 0.8 percent. Any percentage of frequency variation in the source of the phase generator will

TRANSISTORIZED

ILLUSTRATED: MODEL SS-1503

Input: 105-125V, 60-500 cps, approximately 3A.
Output: 100-150V, 0-1.5A.
Ripple: ONE MILLIVOLT RMS.
Regulation: Line, 0.1%, 105-125V. Load, 0.1%, NL-FL.
Transient Response: ZERO-LAGGED for ±10% line transient or ±25% load transient.
Output Impedance: 0.06 ohms at dc. Less than 0.5 ohms, DC-500KC.

Meters: 0-150 volts, 0-2 amperes, 4½" rectangular, 2%.
Size: Standard 19" panel, 5¼" high, 14¾" deep behind panel.
Duty: Continuous, between —20°F and 110°F, 100% humidity, 0 to 10,000 feet.
Polarity: Reversible and floatable to 500V peak from chassis ground.
Price: **$465.** f.o.b. Kenilworth, New Jersey. Generous quantity discounts. **Delivery 15 days.**

NJE

SOLID STATE POWER SUPPLIES

have Everything!

ULTRA COMPACT—More power supply per inch of panel height than ever before!

COOL—Throws less heat into the cabinet than any other type of supply . . . 1/10th the heat generated by vacuum-tube equivalents.

FULLY TRANSISTORIZED—Semi-conductor rectifiers, zener-diode reference standards, transistor series regulators, transistor loop amplifiers.

HIGH STABILITY—Improved high-gain balanced PNP amplifier—prestabilized zener reference.

LOWER PRICE—As much as 30% less than inferior vacuum-tube equipment.

TEN MODELS—Covering 0-300V at 0-1.5 amperes for every plate, bias, and clamp application.

Write for our Solid State Catalog.

NJE corporation
Electronic Development & Manufacturing

371 CARNEGIE AVENUE, KENILWORTH, NEW JERSEY

Competent Engineering Representation Everywhere

NJE LEADS THE POWER SUPPLY FIELD

cause the same percentage of amplitude variation in the output.

The excitation source can be set at any voltage between 10 volts and 115 volts without phase error. Since the ratio of output to input is a fixed parameter, lowering the input will accordingly lower the output and, although phase accuracy remains unaffected, the dial zero will shift. A simple means has been provided to re-zero the dial assembly when excitation is other than 115 volts.

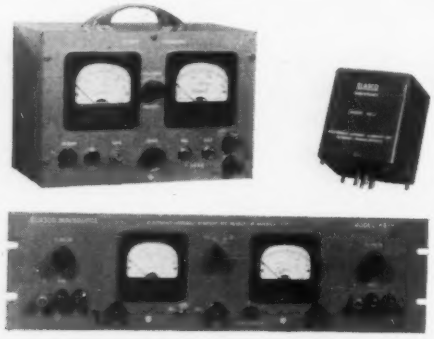
The equivalent circuit of the phase generator output is an impedance in series with a source. Although loading causes attenuation, the phase accuracy and output amplitude variation remain unimpaired.

Another effect of loading causes the zero-degree reference to shift by a constant amount. Unless the load approaches the value of the output impedance, dial re-zeroing is not required.

Transistorized Power Supplies

Another source of transistorized power supplies is now available with the entry of Electronic Assembly Inc.'s Minisource. Marketing a complete line of low voltage units, the Roxbury Mass. company's power supplies vary from 6 to 50 volts with full load current ratings from 50 to 500 ma.

Designed for either 60 or 400 cycle operation, ripple and regulation factors are better than 0.5 per cent; temperature range of operation from −30 to ±65 C. Units have passed shock and vibration tests.



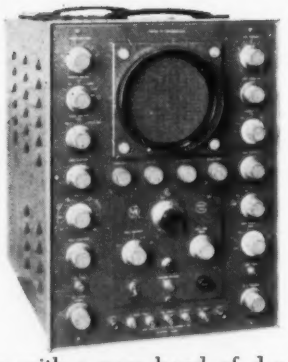
Elasco engineers have packaged their power supplies for various design applications: Top left: 9" x 6" by 5" 16-29 volts 250 ma unit for lab use. Top right: deep-drawn, transformer-cased unit for incorporation with instrumentation. Bottom: special design for a transistorized computer application in which two supplies were combined on a 5¼" x 19" rack panel.

Circle 133 on Inquiry Card

Improved Signal Synchronization For Oscilloscope

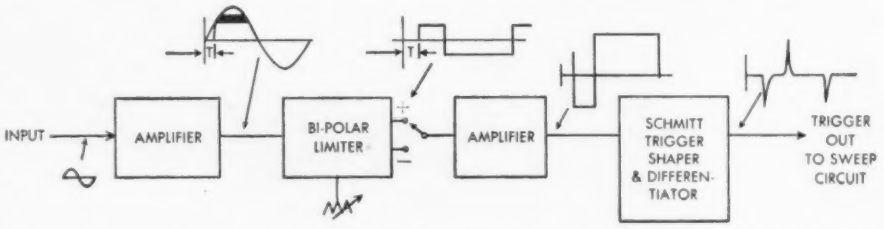
Smooth, automatic trigger synchronization by the vertical input signal over the whole pass band from less than 10 cps to more than 10 Mc is a new improvement in the Model 411A Oscilloscope made by Laboratory for Electronics, Boston, Mass. Easily attained by use of a single control, synchronization is independent of positioning or amplitude adjustments.

Model 411A is a wide band, precision, general purpose oscilloscope for research or production use. Vertical amplifier sensitivity is 20 mv/cm of



display with a pass band of d-c to 10 Mc. Sweep speeds range from 0.1μ-sec/cm to 0.1 sec/cm.

Circle 168 on Reader Inquiry Card



Trigger Amplifier Circuit. Trigger amplifier accepts signals from the vertical amplifier internally or from an external source. Signal is amplified and fed to a bi-polar limiter stage where it is clipped at a level determined by the trigger amplitude control. Amplitude of the pulse coming out of the limiter is constant over the range of input signals which the trigger amplifier accepts. This signal, again amplified, triggers a Schmitt multi-vibrator which insures an output pulse with steep rise time. This signal is then differentiated and triggers the sweep circuits. Amplifier can trigger the sweep circuits with an input signal above 20 mv/cm peak-to-peak. This can be done with sine wave frequencies beyond 10 mc without complicated controls. Once the scope is triggered the sync is unaffected by either positioning or amplitude changes. Since the scope is actually triggered by the incoming signal, scope control is maintained over entire frequency spectrum.

Nuclear Powered Delay Timer

A miniature delay timer with a minimum use life or shelf life of 25 years and reliability under extremely adverse environmental conditions has been developed by use of a nuclear battery (Fig. 1) and a simple timing circuit.

Time delays from milliseconds to 40 hours can be specified with an accuracy of plus or minus three percent over a temperature range from −65 to 160 degrees F.

A practically unending supply of energy from the nuclear battery permits testing of time interval and energy transfer before use. The battery is a constant current source where the current available is a function of the quantity of radioactive material used. It has a capacitance of 4 mmfds and an equilibrium voltage of the order of 5000 to 10,000 volts.

The unit, designed by the Patterson, Moos Division of Universal Winding Company is 2½ inches in diameter, 1⅞ inches long, weighs 0.4 lbs.

Circle 167 on Inquiry Card

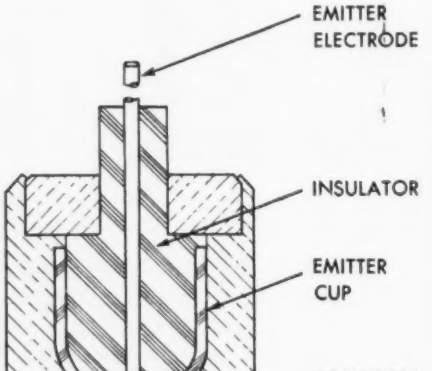


FIG. 1—Diagram of the nuclear battery. An electrically insulated electrode in contact with a beta-emitting radioisotope is one plate of an electrical capacitor. A brass case acts as the collector and other plate of the capacitor. Beta particles emitted by the radioisotope are collected, causing a difference of potential across the capacitor. Because source of battery energy is a radioisotope with a half life of 25 years, the life of the battery is in excess of 25 years.

CURE FOR CRAZY MISSILES

Once airborne, "sick" autopilots are a cinch to spot. Even the boys at the roadblocks can spot them. The trick, of course, is to design those bugs out of the guidance system long before the count-down. It's easy to say. And it's easy to do too . . . with the SERVOSCOPE® servosystem analyzer. You "fly" the complete system through the entire performance envelope, and spot all of the weak points in no time flat with Servoscope.

That's why it's SERVOSCOPE everytime. That's why SERVOSCOPE is THE standard. Most missiles, and nearly every control system, are checked-out with the SERVOSCOPE.

SERVOSCOPE is the *only* servosystem analyzer that performs *all* of the checks necessary for guidance systems . . . an equivalent check-out with other means takes at least six separate instruments and assemblies. That's why you'll find the leading missile builders and suppliers using Servo Corporation's units in their plants.

An entirely different part of the missile's speed record is set by the SERVOBOARD® electromechanical assembly kit. This portable, versatile arrangement expedites mock-ups of any Servosystem and slashes transition time from drawing board to missile "shoot."

Servo-copes and Servoboards can play vital roles in *all* types of servosystems. Want a demonstration? More data? Just send your request to *Technical Information Group, Room D, Servo Corporation of America, 20-20 Jericho Turpnike, New Hyde Park, New York.*

SERVO CORPORATION OF AMERICA

FOR MORE INFORMATION CIRCLE 18 ON INQUIRY CARD

formula for profit!

SPARTA'S CUSTOM MOLDED TEFLON*

Product wizardry is being worked today by many nationally known companies through the use of Sparta's patented process for custom molding Teflon in thin sections and shapes and heavy parts of Teflon . . . opening the door to many product-improvement and cost-reduction opportunities heretofore thought impossible.

PREDICTABLE PERFORMANCE

If you want a custom molded part of Teflon that will work under severe service conditions and extreme temperature ranges . . . and hold required tolerances . . . SPARTA'S patented process of custom molding is YOUR ONLY ANSWER.

TRAINED FLUOROCARBON ENGINEERS

An experienced staff of Fluorocarbon Engineers . . . men highly trained in designing component parts of Teflon . . . are available to assist in solving all problems you may be experiencing through the use of ordinary flexible materials.

PROPERTIES & CHARACTERISTICS of TEFLON

Teflon is suitable for use within temperature ranges of — 450° F to 550°F; it is flexible and tough, chemically inert, unaffected by corrosives, with extremely high dielectric strength under wide frequency ranges, and low co-efficient of friction.

SPARTA MANUFACTURING COMPANY
DIVISION OF UNITED STATES CERAMIC TILE COMPANY
DOVER, OHIO PHONE 4-2380
WESTERN DISTRICT OFFICE
PHONE ANGELUS 3-6359 LOS ANGELES, CALIFORNIA

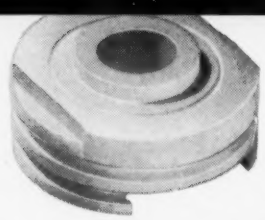
WHEN YOU THINK OF TEFLON . . . THINK OF SPARTA

CUSTOM MOLDED PARTS • FLEXIBLE TUBING • HEAVY WALL and SPAGHETTI TUBING • BACK-UP RINGS • O-RINGS • ROD • SCREW MACHINE PARTS • SHEET • TAPE • SPRAY and DIP COATINGS

THE FIRST COST CAN BE THE LEAST . . . BUT IT IS THE LAST COST!

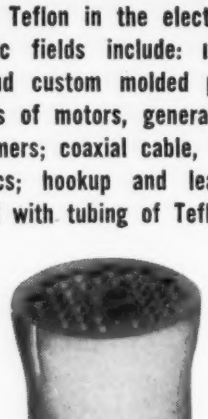
Write for complete data, prices, properties and applications without cost or obligation.

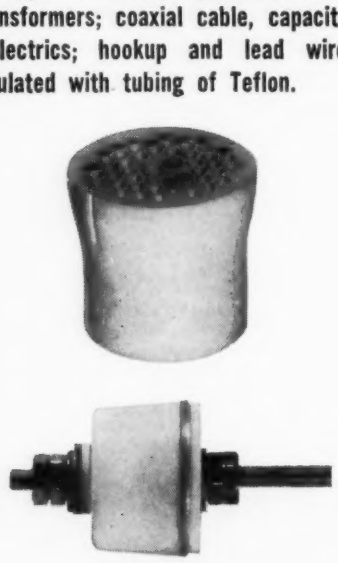
*DuPont's Tetrafluoroethylene Resin

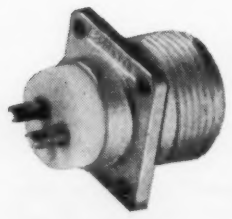


CUSTOM MOLDED PARTS AND TUBING OF TEFLON SIMPLIFIES NEW PRODUCT DESIGNS . . . HELPS SOLVE OLD PROBLEMS!

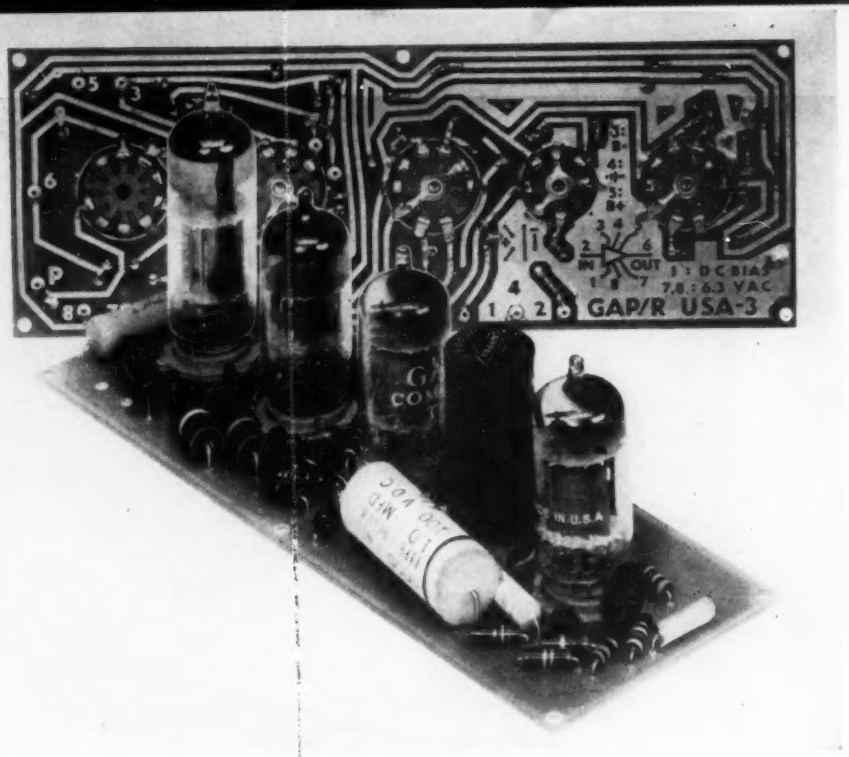
Uses of Teflon in the electrical and electronic fields include: insulation, tape, and custom molded parts for all types of motors, generators, and transformers; coaxial cable, capacitor dielectrics; hookup and lead wires insulated with tubing of Teflon.







Stabilized Operational Amplifier for Electromechanical Designs



With electromechanical engineer's needs in mind, George A. Philbrick Researchers, Inc., Boston, Mass., have combined the circuits of their operational amplifier module and chopper stabilizing amplifier module in one compact printed-circuit unit.

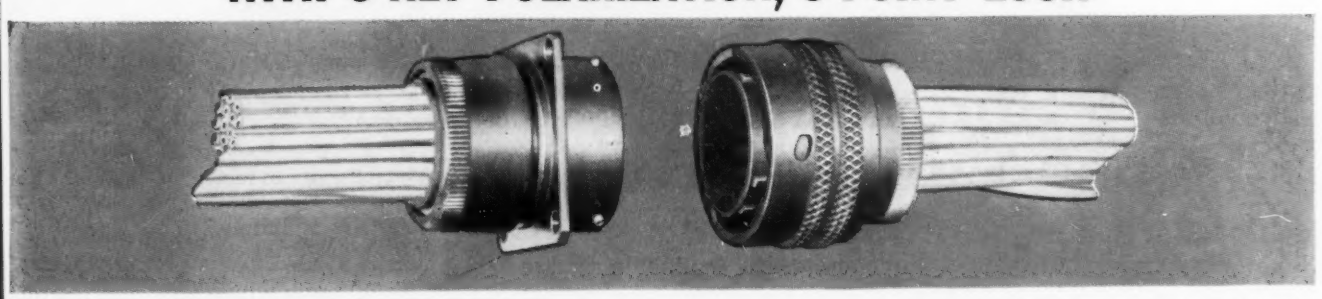
Designed for applications to instrumentation, control and analog computation, it has the extremely high open-loop d-c gain of ten million and is adaptable to mounting in any desired fashion. The unit is applicable where accuracies of d-c operation in the order of 0.1 percent are demanded.

Operational amplifiers are direct coupled amplifiers used as standard components in analog computing equipment to perform mathematical operations and transformations, usually by negative feedback. These versatile units readily perform such basic operations as summing, scaling, integrating, and differentiating and can be implemented to perform combinations of these and other transformations both linear and non-linear with equal facility. They usually have high gain, wide bandwidth, high input impedance for minimum loading, and low output impedance so that reasonable loads may be driven.

Operational amplifiers are also used in electronic portions of closed loop control systems as brains to command the muscles. Error between the desired condition and the existing condition is constantly measured by an input amplifier, then (sometimes by the same amplifier) is amplified, transformed, scaled, and applied through power actuators to the process under control as a corrective force to reduce the error.

For your copy: Circle 249 on Inquiry Card

Bendix "PT" PYGMY ELECTRICAL CONNECTOR WITH 5-KEY POLARIZATION, 3-POINT LOCK



Positive locking feature eliminates safety wiring

The new Bendix* "PT" connector represents the greatest advance yet achieved in miniature connector design. It incorporates more exclusive features than any miniature connector on the market. Here are a few of the things that make the Bendix "PT" outstanding in the connector field today:

- Safety wiring completely eliminated
- Mechanically assisted coupling and uncoupling through cam action
- Visual and audible inspection of coupling—perfect for "blind" locations
- Three-point bayonet lock; perfect axial alignment of mating parts at all times
- Constant spring tension behind mated insert faces
- Five key polarization—positive protection against mismating or cross-plugging
- Resilient inserts, performance-proved in millions of Bendix connectors over the past ten years
- Heavy gold plating over silver on all contacts
- Closed entry, probe-proof socket contacts
- Both pin and socket contacts machined from high-grade copper alloy
- Machined bar stock or impact-extruded shell components cadmium-plated to QQP-416; olive drab iridite after treatment

"PT" connectors accommodate about three times as many circuits, size for size, as comparable "AN" connectors. Like so many Bendix products, they are a result of the traditional Bendix policy of anticipating the needs of the aviation industry, in this case the trend to higher voltages and smaller conductors. *TRADEMARK

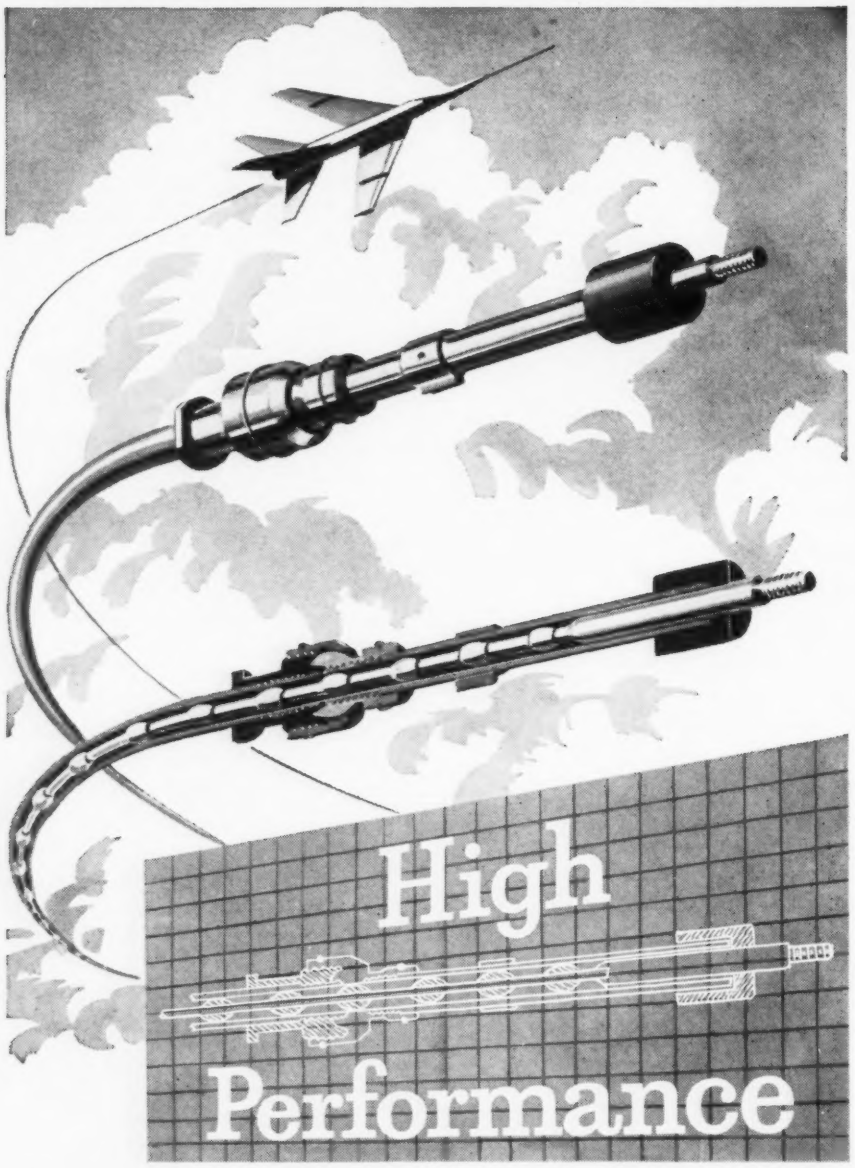
Bendix SCINTILLA DIVISION of SIDNEY, NEW YORK Bendix AVIATION CORPORATION

Export Sales and Service: Bendix International Division, 205 East 42nd St., New York 17, N. Y.

FACTORY BRANCH OFFICES:

117 E. Providencia Ave., Burbank, Calif. • Paterson Building, 18038 Mack Ave., Detroit 24, Mich. • 545 Cedar Lane, Teaneck, N. J. • 5906 North Port Washington Rd., Milwaukee 17, Wisc. Hulman Building, 120 W. Second St., Dayton 2, Ohio • 2608 Inwood Road, Dallas 19, Texas • 8425 First Ave., South, Seattle 8, Washington • 1701 "K" Street, N.W., Washington 6, D. C.

FOR MORE INFORMATION CIRCLE 20 ON INQUIRY CARD



Simmonds Push-Pull Controls

For dependability in transmitting mechanical motion, in rigid or highly flexible casings, choose SIMMONDS Push-Pull Controls. These versatile systems are precision engineered to critical aviation requirements—they MUST work with positive action and stand up in exacting service, light or heavy. In stainless steel, aluminum, alloy steel or combinations, they withstand high frequency cycling, for simple or complex routings. They are vibration resistant, easy to maintain. For aviation, marine, automotive, railroad, farm machinery and many industrial uses.

Available in a variety of sizes and weights for standard controls, or custom-designed to meet your specifications. Write on your company letterhead for detailed design portfolio.

Simmonds AEROCESSORIES, INC.

General Offices: Tarrytown, New York • Branch Offices: Detroit, Michigan Dayton, Ohio • Washington, D.C. • Dallas, Texas • Wichita, Kansas • Glendale, California • Seattle, Washington.
Sole Canadian Licensee: Simmonds Aerocessories of Canada Limited • Montreal

FOR MORE INFORMATION CIRCLE 21 ON INQUIRY CARD

CONTROLLABLE INDUCTORS

Ideas for R-F Switching

Controllable Inductors are proving increasingly useful as electronic commutators in radio frequency circuits. Here are some useful design ideas and techniques sent to us by Elton T. Barrett, President of CGS Laboratories, Inc. But first some background information.

In operation, a controllable inductor is the same as a saturable reactor except that the materials and configuration have been selected to permit operation at high frequencies—up to 400 mc (Fig. 1). Elimination of moving parts is important in field use where the requirement for equipment with a long and trouble-free life is dominant.

"Switching action of controllable inductors is rapid," reports Mr. Barrett, "and can be controlled by a modest direct current resulting in maximum flexibility of control and programming in connection with the associated control circuitry. Logic circuitry can be made to control the switching action automatically in response to almost any predetermined set of conditions.

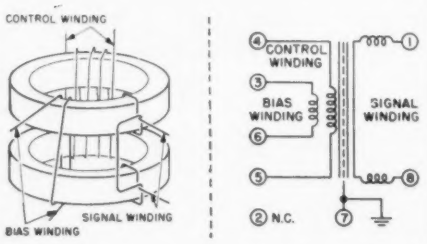


FIG. 1—Construction of one type of controllable inductor useful in RF switches. Two ferrite ring cores carry a control winding and a signal (controlled) winding. When a direct current is applied to the control winding, the effective inductance of the controlled winding decreases as the ferrite core becomes saturated. A balanced signal winding and internal shielding reduce capacitive coupling and transformer action between control and signal windings to a small value.

"Controllable inductors provide attenuation changes of 40 to 80 db. In most applications insertion loss of 0.1 db can be achieved at frequencies up to a few megacycles, increasing to 1 or 1.5 db at 400 mc."

Design of the inductors and the cir-

cuit for such a radio frequency switch depend upon:

- Frequency and bandwidth of the signal to be switched
- Maximum attenuation required
- Loss that can be tolerated
- Switching time
- Repetition rate at which the signal is to be switched
- Number of switching elements and combinations required
- Isolation required between control circuits and radio frequency switching circuits

ON-OFF SWITCH

Fig. 2 illustrates a design for "on-off" operation. A control circuit is arranged so that as the inductance L_1 increases in magnitude, the inductance L_2 decreases and vice-versa. This design can be accomplished in a number of ways so that a single control current can simultaneously increase the inductance of one winding and decrease the inductance of the other. For example, one of the inductor cores can be maintained normally in a saturated condition either by a permanent magnet or a separate bias winding carrying a steady d-c bias current.

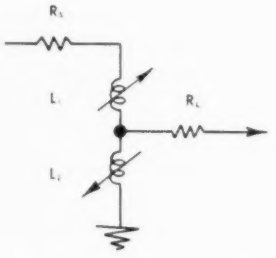
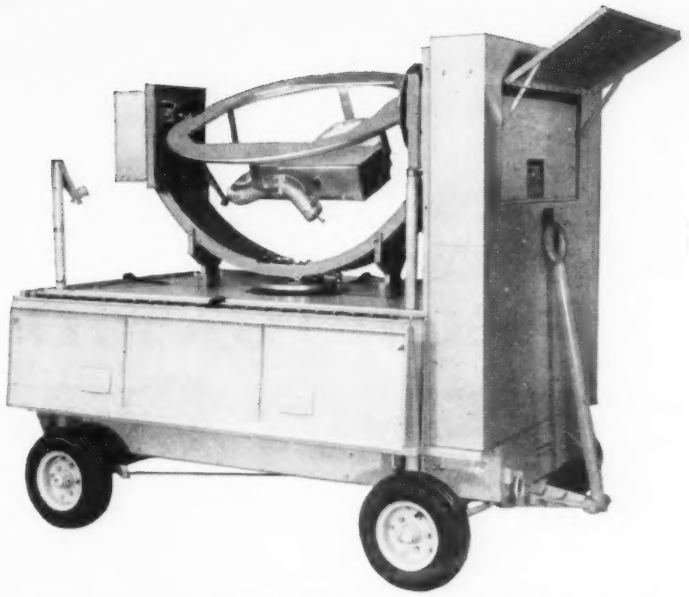


FIG. 2—Operation of a simple controllable inductor switch arranged only for "on-off" operation. Rs indicates the impedance of the source of the radio frequency signal to be switched, and RL indicates the impedance of the load circuit connected to the switch. L_1 and L_2 represent the inductances of the signal windings of two controllable inductors.

The control winding is connected so that the flux produced by it opposes the bias flux and the control current increases the inductance of the associated signal winding while decreasing the inductance of the other control winding. When the two units are alike, insertion loss of the switch is L_{min}/L_{max}, where L_{min} and L_{max} respectively denote the minimum and maximum inductance values of the windings L_1 and L_2. This value is typically about 0.1 db up

continued on page 30



New servo-controlled "Tilt Table" for missile guidance testing

This Thompson-engineered mobile unit aids in the functional check of an intercontinental missile's internal guidance gyroscopes. It generates angular position and velocity inputs to the gyros. Unit consists of electro-mechanical assembly, electronic pre-amplifiers and pick-off amplifiers, and quadrature rejection unit. Two-gimbled support structure will carry a 125-lb. guidance package.

New Actuator operates for 100 hours at 550°F submerged in jet fuel

Pictured is a new Thompson-developed actuator used in missiles. It consists of motor, gearing, feed-back pick-off and jacket. Unit has been tested for 100 hours of operation at 550°F submerged in jet fuel. Power output is 10 watts (mechanical). Torque output is 150 inch-ounces at 30 rpm at 550°F. Servo performance in conjunction with a computor produces a positional accuracy of ±½ degree. Approximate size: 3″ diameter x 4″.

Call on Thompson for development and production of electronic control sub-systems and components, countermeasures and microwave components. We invite your inquiries.

ELECTRONICS DIVISION

Thompson Products, Inc.

2196 Clarkwood Road, Cleveland 3, Ohio

FOR MORE INFORMATION CIRCLE 22 ON INQUIRY CARD

DALES "Temp-Guard"

Pre-calibrated THERMOSTATS and MOTOR PROTECTORS

SPECIFICATIONS

DR M

CASES: Copper, aluminum, anodized aluminum or nickel. Live or dead cases.

INSULATION: Triple-wall Fiberglas — impregnated; dust-proof, moisture-proof, hermetically sealed for immersion or compression, or sealed for varnish dipping and baking.

CONTACTS: Fine Silver or special alloys to meet specific application requirements — totally enclosed.

TERMINALS — LEADS: Furnished to your specifications. Enjoy new production line economy of time and money.

CAPACITY: Standard models up to 1/4 H. P. UL Approved: 3 to 15 amps. 115v ac or 1.5 to 7.5 amps, 230v ac.

TYPE: SPST — Normally Open and Normally Closed contact arrangement. Bimetal type — friction strip models to increase operating differential where desired.

GROUP FUSING TEST: 5000 amps — Limited Short Circuit

ENGINEERING DATA AND SAMPLE THERMOSTATS ON REQUEST. Or, send in your specifications for a prompt solution of your temperature control problem.

THE FRANKLIN DALES CO.

FD Temp-Guard Thermostats

CIRCLE 23 ON INQUIRY CARD

The Time Has Run Out . . .

when timing control can be left to anything but the most dependable and accurate units available for the task.

General Control Company has developed a superior Electronic Timer for relatively short timing periods (i.e. 60 milliseconds to 60 seconds) for the automatic control of industrial operations, equipment and processes.

- Standard plug-in condensers and tubes for ease of replacement.
- Easily accessible terminals.
- Prompt delivery.

Write for Bulletin **ET-600** or see our catalogs in Radio's Master or Sweet's Product Design File.

TYPE ETB

Enclosed or bare chassis models to suit your application.

GENERAL CONTROL COMPANY
1199 Soldiers Field Road • • Boston 34, Massachusetts

SWITCHING TIMING

CIRCLE 24 ON INQUIRY CARD

to a few megacycles, increases to about 0.3 db at 150 megacycles and rises to 1 or 1.5 db at 400 megacycles. Maximum available attenuation is L_{max}/L_{min} and an attenuation of 40db is typical.

If we define the lowest and highest operating frequencies of the switch as those at which there is a 3 db loss caused by L_1 and L_2, and if the load impedance R_L is assumed to be equal to the source impedance R_S, then at the lowest frequency of operation

$$2W_1\ L_{max} = R_S$$

and at the highest frequancy of operation

$$W_2\ L_{min} = R_L$$
$$W_1 = R_S/2L_{max}$$
$$W_2 = R_S/L_{min}$$
$$W_2/W_1 = 2L_{max}/L_{min}$$

Typically L_{max}/L_{min} is equal to 100, indicating that a maximum range in frequency of the signal to be switched is about 200:1 and approaches $(L_{max}/L_{min})^2$ if L_1 and L_2 are not alike.

Control power required to perform this switching operation is less than 5 milliwatts per square wave cycle per second. Total control power increases rapidly with requirements for increased attenuation or switching rate.

When the cores are saturated the Q of the inductances L_1 and L_2 is generally in excess of 100 and is always higher than 50.

HIGH ATTENUATION DESIGN

"Where greater attenuation is necessary," adds Mr. Barrett, "the switching elements can be connected in series (Fig. 3a). With the same controllable inductor characteristics as described above, a maximum attenuation of 80 db can be achieved with 0.2 db insertion loss.

"Switches with even greater attenuation can be made in the form of filters (Fig. 3b). Such a filter switch will

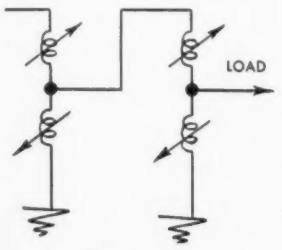
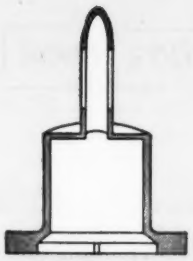
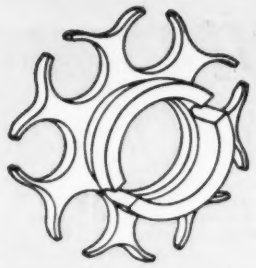


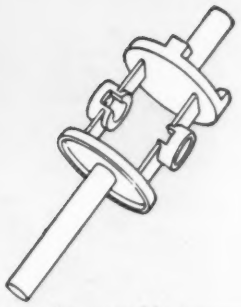
FIG. 3a—Switching elements in series for greater attenuation.



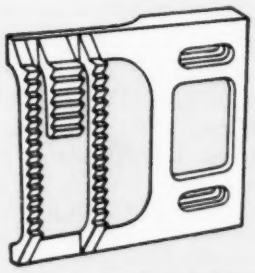
Here is an example of the complex internal coring possible with investment casting. Square, round, elliptical or irregular interiors can be cast.



The complexity of this part makes investment casting the only feasible method of manufacture. Prongs have perfect dimensional accuracy.



Here an entire assembly incorporating multiple functions is cast in one unit. "Keyhole" coring and a number of distinct surface details are required.

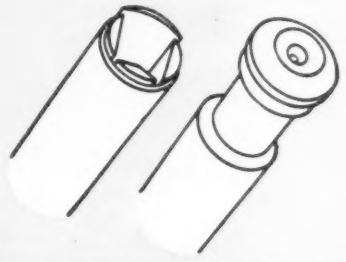


The sharp teeth of this sewing machine feed dog were cast in wear-resistant alloy to give longer wear than could be obtained from machinable material.

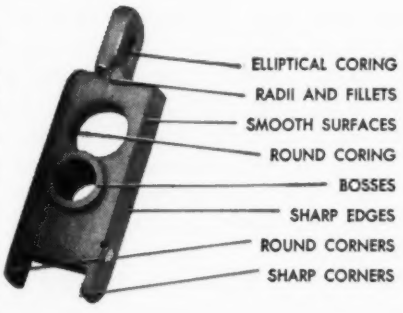
design with **austenal** in mind

In planning parts, design directly for Microcast and take advantage of its wide range of design possibilities.

See not only what you can do, but what costly, time-consuming operations Austenal investment casting eliminates.

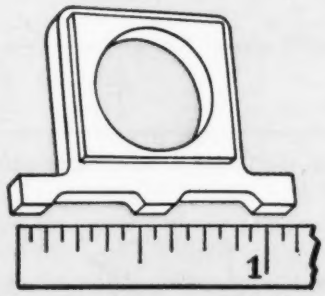


Cross-sections of irregular and varying thickness can be utilized. In this part the internal core diminishes from an irregular square to a small round hole.

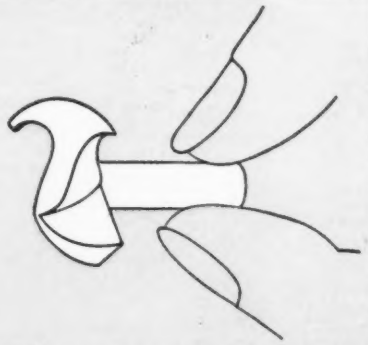


These extrusion dies of wear-resistant alloy are readily mass-produced with highly complex and irregular internal contouring.

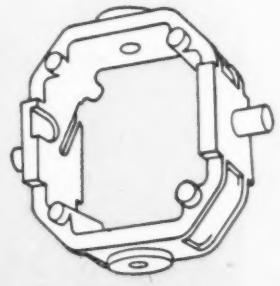
Walls of varying cross-sections are possible. Here wall thicknesses change from thin to very heavy, allowing strength without bulk.



This very small part measures 1⅛" wide and less than ⅛" thick. Its thinness, rigidity and detail were possible only by investment casting.



Shown here is an example of how investment casting can virtually eliminate hand-filing and machining by keeping uniform, intricate detail.



This large complex gimbal was cast to include many details on the internal and external surfaces.

Design problem?

Call your Austenal representative and ask him to show you how Microcast can help you.

FOR MORE INFORMATION CIRCLE 25 ON INQUIRY CARD

PRECISION CASTINGS

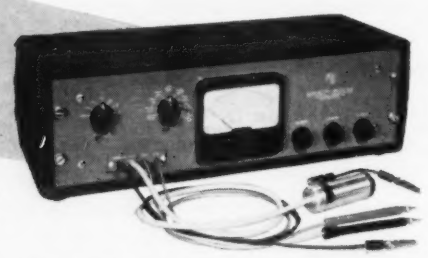
austenal ®
INC.
microcast division
224 EAST 39th STREET, NEW YORK 16, N. Y.

Another **NEW** **VTVM** *from*

ACTON laboratories

Acton Laboratories has done it again! Here is another fine vacuum tube voltmeter, the Type 815-A, which follows right on the heels of the Type 810 recently announced. The 815-A has been especially designed for use in the laboratory — on the bench or in a rack. Independent zero adjustments for AC, DC, and resistance measurements insure accurate meter readings. Regulation of both plate and filament voltages in the power suppiy insures stability.

The Type 815-A has 9 full scale DC ranges: 0.1-1000 volts (+ or −); 8 AC ranges: 0.1-300 volts (rms); 9 DC current ranges: 0.001 ua to 100 ma; 9 resistance ranges: 0.2 to 500 with multipliers X0.1 to X10 meg. DC accuracy is ±2%, AC accuracy is ±3%, both on the 1 volt range and higher. Frequency response is 15 cps to 100 mc. DC input impedance is 100 meg; AC input impedance is 5 mmf and 10 meg.



For more information on the new Type 815-A, write or call:

ACTON LABORATORIES, INC.

533 Main St., Acton, Mass. COlonial 3-7756

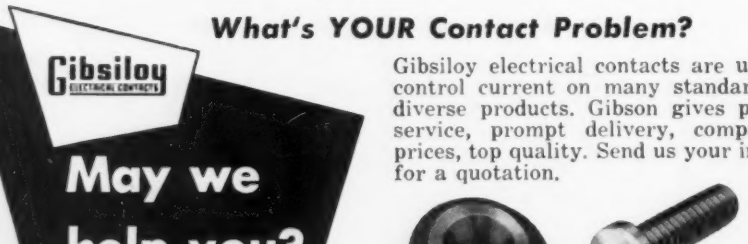
CIRCLE 27 ON INQUIRY CARD

What's YOUR Contact Problem?

Gibsiloy ELECTRICAL CONTACTS

May we help you?

Gibsiloy electrical contacts are used to control current on many standard and diverse products. Gibson gives prompt service, prompt delivery, competitive prices, top quality. Send us your inquiry for a quotation.



Write for Catalog C-520

or see our catalog in Sweet's Product Design File

Call Your Nearest GIBSON Office:

BOSTON
Gil L. Pike
370 Upham Street
Melrose 76, Mass.
MElrose 4-6941

CHARLOTTE
W. K. Hile
117 E. Third St.
Charlotte 7, N. C.
FRanklin 5-0365

CHICAGO
Hill-Grey, Inc.
41½ Harrison Street
Oak Park, Ill.
EU 3-0373—
TWX Oak Park 202

CLEVELAND
Robt. R. Stone Associates
1925 Lee Road
Cleveland Heights 18, O.
Erie View 1-4484

DETROIT
W. K. Cochrane Assoc.
308 Security Bldg.
Jackson, Mich.
STate 2-8282

INDIANAPOLIS
R. D. O'Connell Co.
4515 Berkshire Rd.
Indianapolis 18, Ind.
LIberty 7-7600

LOS ANGELES
E. A. Wilcox Co.
6436 East Corvette St.
Los Angeles 22, Calif.
RAymond 3-6436

NEW YORK
W. M. Hicks
4 Spruce Drive
Roslyn, L.I., N.Y.
MAnhasset 7-6150

PHILADELPHIA
Cashman & Norton, Inc.
Box 124
Broomall, Pa.
ELmwood 7-7703
ELgin 6-7703

ROCHESTER
Judson H. Scott
630 Seneca Parkway
Rochester 13, N. Y.
GLenwood 3-2208

ST. LOUIS
Robert B. Stahlhut
320 Woodside Drive
St. Louis 22, Mo.
VOlunteer 3-2800

SAN FRANCISCO
E. A. Wilcox Co.
277 Seventh Street
San Francisco 3, Calif.
HEmlock 1-6670

SEATTLE
E. A. Wilcox Co.
915 Arctic Building
Seattle 4, Wash.
Mutual 1468

EXPORT DEPT.
Bessemer Building
Pgh. 22, Pa.GR 1-7217
Cable: INLEXPORT

Gibsiloy ELECTRICAL CONTACTS

Manufactured by
GIBSON ELECTRIC COMPANY

BOX 654, DELMONT, PA.

CIRCLE 26 ON INQUIRY CARD

provide an attenuation of 12db/octave per section. The three section filter shown will provide, in typical switching operations, an attenuation of 120db. Similar switching functions can be performed with high-pass filter configurations.

"Variable inductor switches can be arranged to switch between two sources (Fig. 3c), or between a number of sources (Fig. 3d). Inductances L_1 through L_4 (Fig. 3d) are controlled so that the inductance of any selected one can be reduced to its minimum value, thus providing an instantaneous switching connection between any one of the sources and the load circuit."

HIGH POWER CIRCUITS

The RF switches described are used primarily in low power circuits. Higher power switches for transmitting and other applications have been developed.

Isolation expressed as a voltage ratio between the control voltage and the signal voltage in a typical production controllable inductor is approximately equal to ten times the ratio of control turns to signal turns. When the windings are balanced with a special design, the factor of ten increases to 100 or more where such complete isolation is necessary. Increased isolation can be obtained, when the control and signal frequencies are different, by placing a filter in series with the control windings to suppress the undesired frequency components.

Such switches are finding use also in applications where a continuously

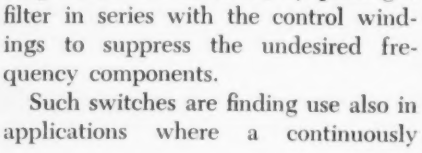


FIG. 3b—Switches with greater attenuation in filter form.

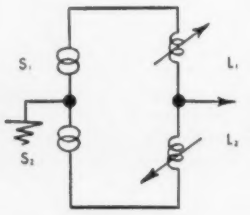


FIG. 3c—Circuit diagram for switching between two sources.

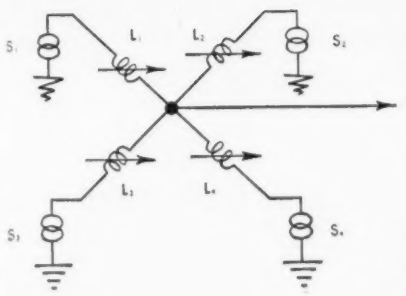


FIG. 3*d*—Circuit diagram for switching between many sources.

smooth transition between "off" and "on" conditions is necessary, as, for example, in automatic gain control circuits.

In such uses, they have the advantages of wide control range (40 to 80 db), introduce no cross modulation, and do not cause any change in plate current of the tubes and therefore no change in the B+ voltage even with poorly regulated supplies. A single diode will in most cases handle the necessary control power.

In some switching applications production units can be used, but it is usually necessary to modify the inductors or to design new ones with the best characteristics for the intended use. The control circuitry for the switches must be closely coordinated with the inductor design. For this reason you should check with your source of supply for the complete switch package including the control circuits.

Controllable inductor switches are new and no one can say to what extent they will be adopted for various uses. Those so far constructed exhibit characteristics that appear likely to make them desirable for a variety of applications. In installations where the switching action is to be controlled remotely, use of controllable inductors offers obvious advantages.

Development of better controllable inductor switches is being aided by improvements in controllable inductors. Recent developments have markedly reduced the control power required to saturate the ferrite, permitting the design of switches requiring substantially less reactive power in the control circuits than was possible previously.

If you'd like to receive information about circuit designs using variable saturable reactors, circle 245 on the Reader Inquiry Card.

The story is in these two bulletins:
Small zinc alloy die castings exclusively
Injection molded tiny NYLON (other plastic) parts
GRC exclusive patented techniques guarantee precise tolerances and uniform quality . . . offer broad design flexibility. GRC saves, too, by doing it in one high-speed operation . . . no trimming, no assembly, no scrap loss.

That's why the *BIGGEST PART* of our business is the LITTLE PART . . . in the product you make.
Write, wire or phone TODAY for these bulletins.
Better still send your prints for quotation.

Maximums.
Zinc Alloy 1¾", ½ oz;
Plastic 1¼", .03 oz.
NO MINIMUM SIZE!
Quantities from 100,000 to millions.

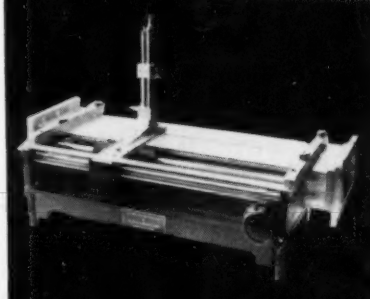
GRIES REPRODUCER CORP.
World's Foremost Producer of Small Die Castings
119 Beechwood Ave., New Rochelle, New York
NEw Rochelle 3-8600

GRIES

CIRCLE 28 ON INQUIRY CARD

DICO

Antennas
Feed Systems
Rotary Joints
Slotted Lines
RF Heads
Horns
Diplexers
Filters
Duplexers
Water Loads
Transitions
Attenuators
Directional Couplers
Crystal Mounts
Magnetron Plumbing
Bolometer Mounts
Waveguide Mixers
Crystal Mixers
Stub Tuners
Waveguide Tuners
Hybrid Rings
Frequency Meters
Waveguide Assemblies
Coaxial Assemblies
Tee Sections
Terminations
Dummy Loads
Phase Shifters
Klystron Mounts
Shorts
Adapters
Line Stretchers
UG Flanges
Bends
Twists
Accessories



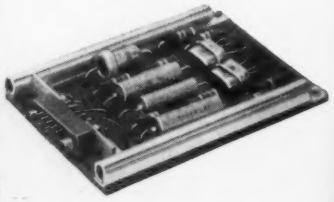
DIAMOND, with its policy of diversified expansion now offers a complete ONE SOURCE facility for design and manufacture of Antenna Systems, Microwave Components and Test Equipment.

Write for Catalog

DIAMOND
ANTENNA & MICROWAVE CORP.
7 North Avenue • Wakefield, Massachusetts

CIRCLE 29 ON INQUIRY CARD

NEW! Miniature Transistor Computing Amplifiers



Model 807 Cover-Off View

8000+ hours in operation with no failures and still going!

Here for the first time are lightweight, critically accurate computing amplifiers offered on an *off-the-shelf* basis!

Smaller than a package of cigarettes, each of these 400 cps AC amplifiers has shown:

- High stability and accuracy
- Environmental tested reliability. —55°C to +85°C
- Excellent operating efficiency. Better than 90%

MAXSON MAKES IT

SPECIFICATIONS

807 Series Summation Amplifier: Output Voltage (rms): 8 (into 3,500 ohms); Phase Shift: less than 0.15°; Accuracy: ±0.1%; Typical Load: Mark 4 Mod O resolver*.

807-1 Preamplifier: Output Voltage (rms): 4 (into 5,000 ohms); Phase Shift: less than 0.15°; Typical Load: 5,000 ohms.

808 Parallel Summation Computing Amplifier: Output Voltage (rms): 22 (into 3,500 ohms); Phase Shift: less than 0.15°; Accuracy: ±0.05%; Typical Load: Mark 4 Mod O resolver*.

809 Automatic Gain Control Computing Amplifier: Output Voltage (rms): Max. undistorted output 0.4 volt into 10,000 ohms; Phase Shift: less than 5°; Typical Load: 10,000 ohms.

*On special order for use with other resolvers. All silicon transistors and diodes.

MAXSON INSTRUMENTS

47-37 Austell Place
Long Island City 1, New York

Division of The W. L. Maxson Corporation

CIRCLE 30 ON INQUIRY CARD

Ronald C. Vickery STAFF COLUMNIST

Ronald C. Vickery is Head of Horizons Incorporated's Chemistry Department

THE CHEMISTRY OF COMPONENTS

COMING

—Rare Earth Storage Battery?
—Rare Earth Ferrites?

The steadily increasing scope and applications of electronics science and electromechanical design have placed a growing emphasis upon the chemistry of their components. Perhaps "chemistry" is rather an incorrect term and "solid state science" would be preferable; in electronics the overlap of chemical and physical sciences is such that no adequate line of definition exists.

Studies in this area probe into increasingly novel directions as electromechanical component requirements become more precise and better understood. Inevitably, elucidation of electronic phenomena and orientation of system parameters will lead into the hinterland of existing knowledge and into studies of elements and compounds hitherto considered as laboratory curiosities and museum pieces. And inevitably, studies will focus upon those elements and compounds whose properties are less known and understood.

Of the hundred or so elements now known within the Periodic Table, the transition-type elements, because of the peculiar nature of their electronic shells and their lesser known chemistry, have been the subject of increasing studies. The more peculiar transition series—those of the rare-earth and actinide groups—present several features of structural and chemical interest which would seem to suggest possession of interesting, and possible new, electronic properties. The extreme rarity of members of the actinide series ($Z = 89$ to $Z = 100$) militates somewhat against studies of their applications; but, since their properties are to a wide extent paralleled by those of the rare-earth series, examination of the rare earths yields a twofold result.

The chemistry, physics, and general applications of the rare-earth elements and their compounds have been covered in several textbooks and treatises. In this and future columns we shall cover only those aspects and developments that will be of direct interest to electromechanical development and design engineers. Today's column presents for further thought and possible application some lesser known areas in which rare-earth elements and compounds present direct potentialities.

STORAGE BATTERIES

The development of new electrochemical systems for batteries and dry cells is of constant importance because of size, voltage and life requirements. Several known systems otherwise applicable are incapable of maintaining a steady output voltage because of gradual polarization. Since polarization is known to be inhibited by the presence of cerium salts, any cell based upon such salts should be self-depolarizing.

Let's consider the possible development of a primary battery based upon ceric sulphate; ceric ions are reduced to the cerous state producing electrons. Preliminary investigations in such a cell have produced interesting results.

When we immersed platinum and "misch metal" electrodes in a solution of cerous-ceric sulphate, we produced an electrical discharge of up to 2.2 volts. Further experiments showed that the same effect could be obtained with the electrodes inserted in a solid packet of ceric sulphate. Although the amperage obtained was generally low, it is conceivable that this may be increased by using porous electrodes such as those from sintered magnetite.

One deficit of the cell thus far produced lies in the gradual deterioration of the "misch metal" electrode by oxidation of the iron contained while output appears related to degree of hydration of the system. Theoretical examination of a Ce^{3+}/CE^{4+} system shows

Early European Glass Blower

when you have ken ✻ you can!

ESC HAS THE KNOW-HOW AND EXPERIENCE REQUIRED TO PRODUCE CUSTOM-BUILT DELAY LINES TO YOUR EXACTING SPECIFICATIONS.

1st in sales!

1st company devoted *exclusively* to the manufacture of delay lines!

1st in research, design and development of custom-built delay lines!

1st to submit the most definitive laboratory reports with all custom-built delay line prototypes!

✻ **ken**—vision, knowledge, perception... as, ESC has the ken to produce the finest custom-built delay lines in use today.

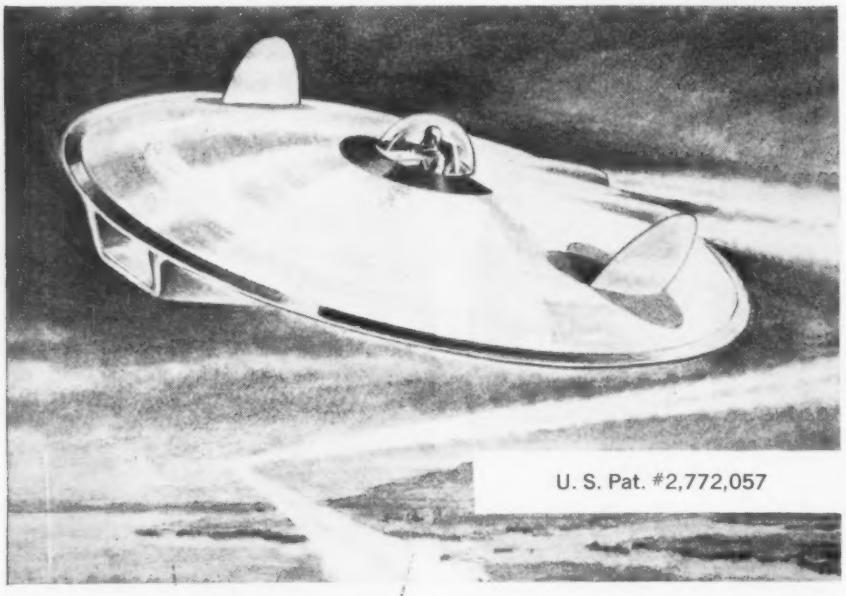
Exceptional employment opportunities for engineers experienced in pulse techniques.

ESC® CORPORATION

534 Bergen Boulevard, Palisades Park, New Jersey

FOR MORE INFORMATION CIRCLE 31 ON INQUIRY CARD

MARS outstanding design **SERIES**



U. S. Pat. #2,772,057

saucer secret?

Whose incredible design is the flying saucer?

These flying objects (unidentified, of course) maneuver at high speed, with human-crushing suddenness. Their unearthly behavior poses a perplexing problem to imaginative designers: how might man survive in them?

John C. Fischer, Jr. approached the problem with this circular aircraft and its unique control system, U. S. Pat. #2,772,057.

This "saucer's secret" is a rotatably adjustable shell (upper) and a pilot's compartment which *pre-rotates* toward the direction to be flown. The functional design "humanizes" saucers because the rotating provisions distribute *g-forces* laterally on the pilot, minimizing blackouts.

No one can be sure which of today's new ideas will become reality tomorrow. But it will be important then, as it is now, to use the best of tools when pencil and paper translate an idea into a project. And then, as now, there will be no finer tool than Mars—from sketch to working drawing.

Mars has long been the standard of professionals. To the famous line of Mars-Technico push-button holders and leads, Mars-Lumograph pencils, and Tradition-Aquarell painting pencils, have recently been added these new products: the Mars Pocket-Technico for field use; the efficient Mars lead sharpener and "Draftsman's" Pencil Sharpener with the adjustable point-length feature; and—last but not least—the Mars-Lumochrom, the new colored *drafting* pencil which offers revolutionary drafting advantages. The fact that it blueprints perfectly is just one of its many important features.

The 2886 Mars-Lumograph drawing pencil, 19 degrees, EXEXB to 9H. The 1001 Mars-Technico push-button lead holder. 1904 Mars-Lumograph imported leads, 18 degrees, EXB to 9H. Mars-Lumochrom colored *drafting* pencil, 24 colors.

J.S. STAEDTLER, INC.
HACKENSACK, NEW JERSEY

at all good engineering and drawing material suppliers

FOR MORE INFORMATION CIRCLE 32 ON INQUIRY CARD

that for pure cerium (free from iron and other impurities) emf values of 3.5 – 3.8 electron volts should obtain; thus in the ceric sulphate cell using "misch metal" as an electrode, the potential of 2.2 volts can undoubtedly be increased by the use of iron-free cerium metal.

Rejuvenation of such a ceric-sulphate cell may readily be possible by reversing charges at the electrodes, thus reoxidizing the cerous sulphate produced to the ceric state, or by chemical reoxidation with ammonium persulphate.

A possible extension of this development could utilize an ion-exchange resin system "loaded" with ceric ions as the source of current. Any "solid low in internal resistance and of simple state" battery made this way should be construction.

FERROMAGNETICS

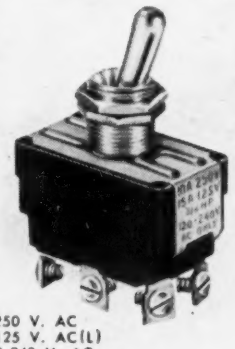
The outstanding advantage in electronics science of nonmetallic ferromagnetic compounds is their low electrical conduction and, therefore, low eddy-current losses at high frequencies. However, many subsidiary qualities are required of such compounds—maximum saturation magnetism, low magnetostriction to give high permeabilities and low hysteresis loss, good thermal and mechanical stabilities. In general, such materials may be found among those oxide systems adopting either spinel (close-packed 0^{2-} ions) or perovskite (close-packed metal and 0 ions) crystal lattices. Systems of the first type are colloquially classed with the ferrites. This is a misnomer since by definition ferrites are formed only between ferric oxide and the oxide of a bivalent metal. Therefore indications of the production of rare-earth ferrites must be reconsidered.

Replacement in the ferrite lattice by rare earths may occur but simply by virtue of their ionic charge. It would not be possible to produce simple rare-earth ferrites, as such, while retaining the spinel structure. The number of metallic ions which can form solid solutions in the spinel structure is great, the primary requirement being that their ionic radii lie between 0.5 and 1 Angstrom units. This requirement again restricts rare-earth ferrite formation to the last four lanthanons (Er, Tm, Yb, Lu) and scandium.

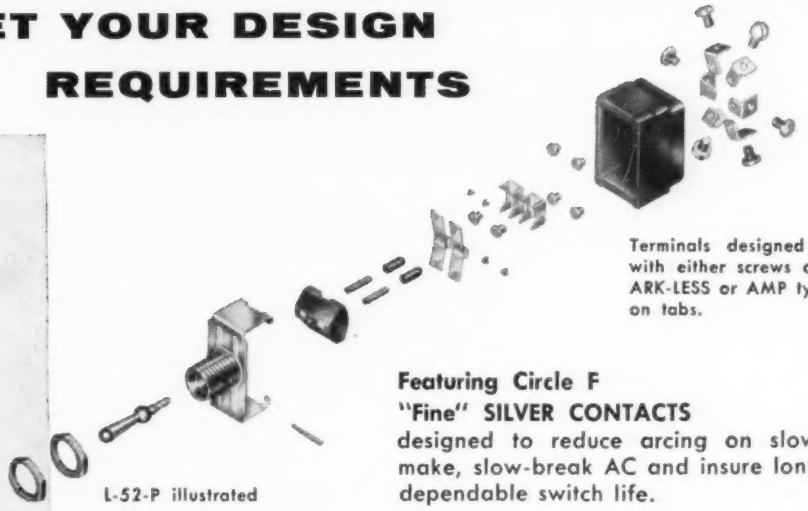
No attempts appear to have been

PRECISION-ENGINEERED CONTROL SWITCHES TO MEET YOUR DESIGN REQUIREMENTS

L-52-P
D.P.D.T.
on-off-on



10 Amp. 250 V. AC
15 Amp. 125 V. AC(L)
¾ H.P. 120-240 V. AC



Terminals designed for use with either screws or female ARK-LESS or AMP type push-on tabs.

L-52-P illustrated

Featuring Circle F "Fine" SILVER CONTACTS designed to reduce arcing on slow-make, slow-break AC and insure long, dependable switch life.

L-40-A
S.P.S.T.
on-off

10 Amp. 250 V. AC
15 Amp. 125 V. AC(L)
¾ H.P. 120-240 V. AC

1887-LP
S.P.S.T.
on-off

3A - 125 V (T)
6A - 125 V
3A - 250 V

L-42-E
S.P.D.T.
on-off-on

10 Amp. 250 V. AC
15 Amp. 125 V. AC(L)
¾ H.P. 120-240 V. AC

2230
S.P.S.T.
on-off

10 Amp. 250 V. AC
15 Amp. 125 V. AC
¾ H.P. 120 V. AC
1½ H.P. 240 V. AC

No. 438-L
ACTUAL SIZE
15 Amp - 125 Volt

Now Circle F offers new economies to design engineers through the use of standard medium-duty, one-hole switches, *available for modification to meet particular specifications.*

New standards of quality-controlled manufacture permit these precision-engineered switches to be *"custom-made"* and delivered in production quantities in *less time* and *at the lowest possible cost.*

Write Department S for full information and engineering assistance

FLUSH MOUNTING, SNAP-IN CONVENIENCE OUTLETS AND SWITCHES

M-2230-H illustrated

FAST, EASY SPRING CLIP INSTALLATION
COMPACTLY DESIGNED — COMPETITIVELY PRICED

Ideally-suited for bathroom fixtures, medicine cabinets, ranges, and other electrical appliances. Snap-in Convenience Outlets and Medium-duty Switches are rated 15 amp, 125 V. Clip will accommodate wall thicknesses of .025" to .095".

Listed by Underwriter's Laboratories, Inc. and certified by Canadian Standards Association

GUARANTEED F WIRING DEVICES

CIRCLE F Mfg. Co.

731 MONMOUTH STREET, TRENTON 4, NEW JERSEY
IN CANADA: VERD-A-RAY ELECTRIC PRODUCTS LTD. MONTREAL
For your wire requirements: Eastern Insulated Wire Corp.
(A Subsidiary)
Box 591, Trenton, N. J.

FOR MORE INFORMATION CIRCLE 33 ON INQUIRY CARD

where reliability counts... superpower by YARDNEY!

In almost every missile today you will find YARDNEY SILVERCEL® batteries
. . . Tested and evaluated at every step—from research and design, through production, field test, and end use—SILVERCEL® batteries have met the rigid requirements of Spec. MIL-E-5272A.

500,000 Yardney silver-zinc cells bought and used by the U. S. Armed Forces!

Compact, up to 5 times more powerful than other batteries, the YARDNEY SILVERCEL® is also used in aircraft, vibrators, dynamotors, portable TV and motion picture cameras, R/C model planes and boats, and many other applications.

To solve your power problem
. . . or for assistance in checking your battery requirements . . . contact our Applications Engineering Department for free consultation service.

FREE TECHNICAL BROCHURE
Containing data on our complete line of Yardney SILVERCEL® and Yardney SILCAD* batteries. Write today! *Trade Mark

Patents pending and granted throughout the world.

YARDNEY ELECTRIC CORPORATION
"Pioneers in Compact Power"
40 Leonard Street, New York 13, N. Y.

©1957 Yardney Electric Corp.

FOR MORE INFORMATION CIRCLE 34 ON INQUIRY CARD

made to prepare authentic "ferrites" of bivalent lanthanons (Sm^{2+}, Eu^{2+}, and Yb^{2+}) although europous titanate has been reported and may be of value as a ferromagnetic. If "ferrite-type" compounds could be prepared of the form, e.g. $SmO–Sm_2O_3$, interesting characteristics might be exhibited since very high μ_{eff} values can be calculated for these compounds. Up to now attempts at this preparation have been unsuccessful.

The perovskite structure also has limiting requirements of ionic size, but a modicum of distortion is permitted in the tolerance (t) which is of the order 0.8 – 1.0 in the equation

$$r_A + r_O = t\sqrt{2}\,(r_B + r_O).$$

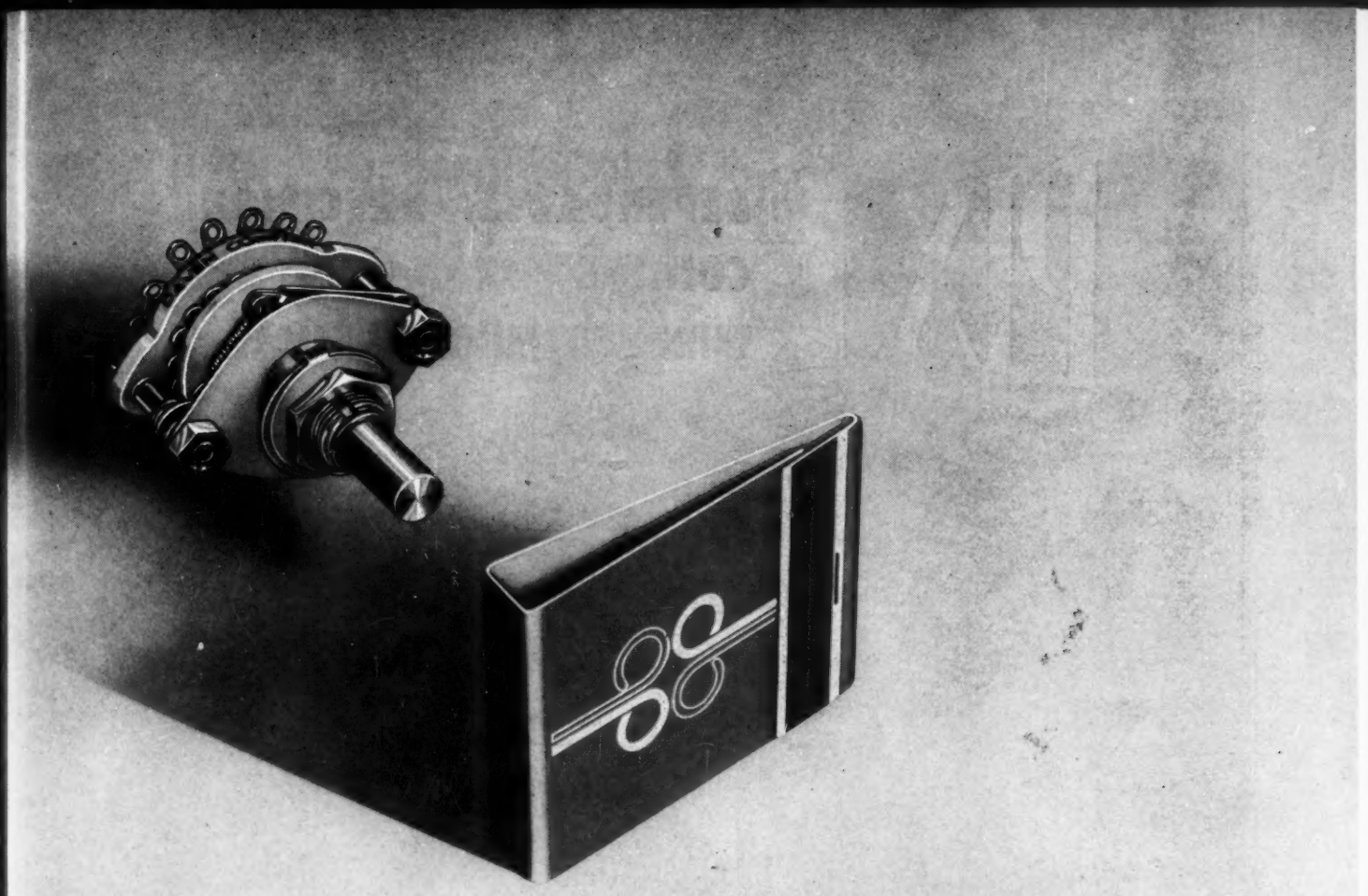
Providing that the ionic sizes are approximately right, the only other requirement is that the structure be electrically neutral; that is, that the sum of the valences of A and B is 6.

Ferromagnetic properties of oxidic compounds of this type, containing the rare earths, are being increasingly examined, and Neel p-type magnetization curves have been obtained. Curie temperatures for the systems generally lie between 250 and 470K, but actual values depend, of course, upon the degree of crystallinity.

Predominant among the "simpler" systems is lanthanum maganite which, on crystallization, is strongly ferromagnetic at room temperature and is believed to display an almost square hysteresis loop. So far this is the only "simple" rare-earth compound exhibiting such ferromagnetism although further developments are conceivable.

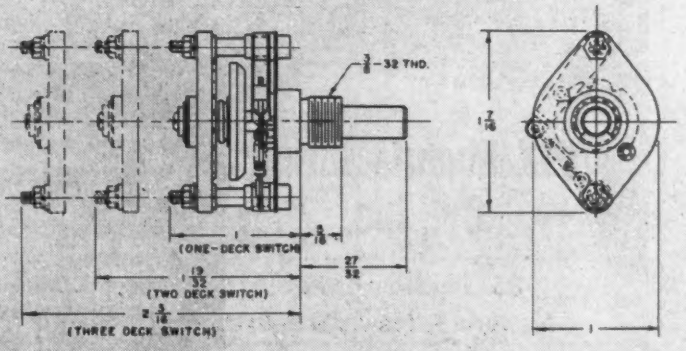
Indications have recently appeared that some consideration which had been given to the structure of perovskite-like compounds may in fact be invalidated by the neglect to consider the possible formation of structures similar to that of pyrochlore. Until recently no references were extant describing a pyrochlore structure which did not contain a pentavalent ion as an essential element of the compound. However, ternary compounds of this type have now been described. Conceivably, in some cases, even when ostensibly only of binary composition, pyrochlore phases may well exist by virtue of the occurrence of impure phases and may well be appreciably ferromagnetic.

In his next and future columns Dr. Vickery will report on potential and soon to come rare earth applications in electromechanical components: semiconducting piezoelectric crystals, solar reduction devices and thermionics.



DID YOU SAY | small? |

Occupying less than 1½ square inches of panel space, this Miniature Ceramic Switch nevertheless contains as many as **18 positions on a single wafer.** And it's rugged! Solid silver alloy contacts, rotors, and slip rings provide low and uniform contact resistance. Ceramic parts are silicone impregnated to function under extreme humidity. Sturdy solder terminals are supplied for wiring. This miniature switch meets and exceeds the electrical and environmental requirements of Mil-Spec S-3786. Flashover voltage at 60 cycles is 1000 volts peak . . . current carrying capacity is 2 amperes. For guided missiles, airborne radar equipment, portable and mobile ground equipment . . . for any application that requires an extremely small and rugged switch, specify Daven's Series M Miniature Ceramic Switches. These units can be "ganged" with up to 8 decks with slight mechanical modifications. 2 or 3 poles per deck may also be obtained as standard. Prototypes can be delivered within 2 weeks.



Write for complete information.

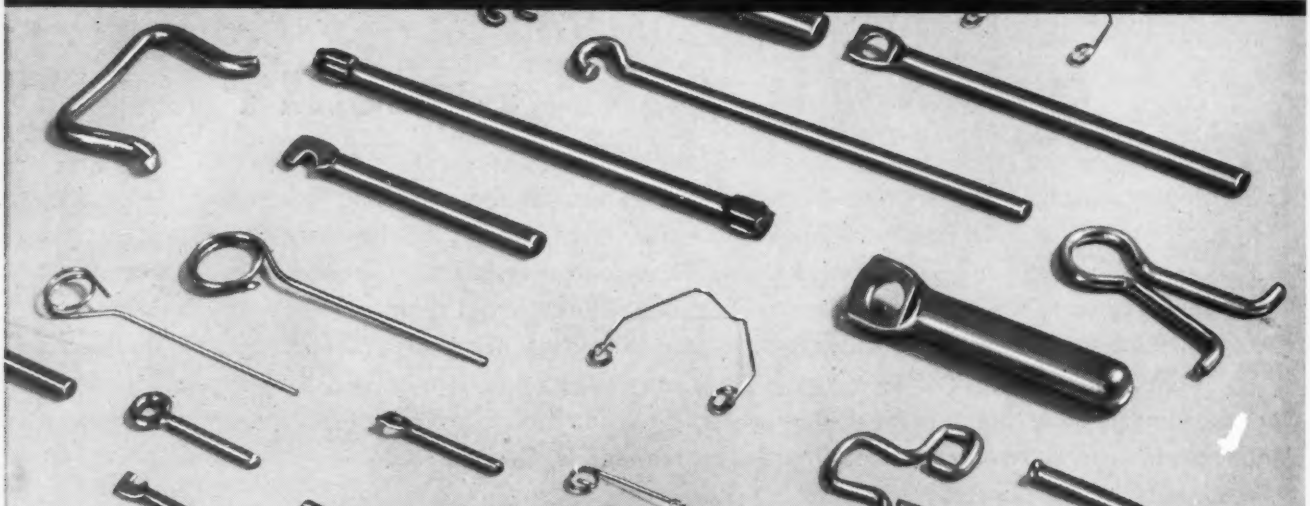
THE DAVEN CO.

Livingston, New Jersey

TODAY, MORE THAN EVER, THE DAVEN Ⓓ STANDS FOR DEPENDABILITY!

PIX

DEPENDABLE, PRECISION COINING, STAMPING AND WIRE FORMING SPECIALISTS



PIX Manufacturing Co., Inc.

85 Hudson Street
Newark 3, New Jersey

To meet your production and engineering needs, PIX can furnish precision wire formings and stampings from .002" dia. to .187" dia.

Radio tube parts, drawings, piercing, wire straightening, cutting and forming, relay components, transistor bases, terminal lugs, multi-slide stampings, beryllium copper contacts, printed circuit connectors—these precision parts can be produced quickly, economically, by PIX's high-production equipment and modern facilities.

WRITE FOR FURTHER DETAILS. SEND SKETCH OR PRINT FOR QUOTATION.

FOR MORE INFORMATION CIRCLE 36 ON INQUIRY CARD

TO MEET PRACTICALLY EVERY APPLICATION...

ENGELHARD THERMOCOUPLES and THERMOELEMENTS

Although the nature and assembly of the components employed in a thermocouple system influence the reliability of the temperature measurement, the accuracy of the system is ultimately determined by the thermoelement used in the thermocouple. The noble and base metal thermoelements used in Engelhard Thermocouples undergo rigid testing in a metallurgical laboratory equipped with specially designed test furnaces and precision measuring equipment. Calibration must meet Engelhard's high quality standard—a standard that has forged a world-recognized reputation for reliability—a standard that assures accurate temperature measurement.

To meet practically every application requirement, Engelhard Thermoelements are available in base metals for measurement up to 2200°F, and in noble metals for higher temperature measurements. The initial cost of a noble metal thermoelement is well justified by the reliability, length of life and easy maintenance factors it provides, as well as its value as scrap when being replaced. In addition to the noble metal thermoelements contained in the chart to the right, thermoelements of Iridium vs. Iridium Rhodium can be supplied to read temperature as high as 3600°F.

A complete line of precision resistance thermometers is available, having accuracy as high as 0.10 degree.

Write for complete catalog material and details.

CHARLES ENGELHARD INCORPORATED
TEMPERATURE MEASUREMENT

850 PASSAIC AVENUE, EAST NEWARK, NEW JERSEY

TO AID YOUR THERMOCOUPLE SELECTION

THERMOCOUPLE TYPE	BASED ON WIRE GAUGE #	TEMPERATURE LIMITS
Copper vs. Constantan	20	-300°F. to 600°F.
Iron vs. Constantan	8	0°F. to 1600°F.
Iron vs. Constantan	14	0°F. to 1200°F.
Chromel vs. Alumel	8	600°F. to 2100°F.
Chromel vs. Alumel	14	600°F. to 1800°F.
Platinum vs. 10% Rhodium	24	Up to 2900°F.
Platinum vs. 13% Rhodium	24	Up to 2900°F.
Platinum 5% Rhodium vs. Platinum 20% Rhodium	24	Up to 3200°F.
Platinum 6% Rhodium vs. Platinum 30% Rhodium	24	Up to 3272°F.

ENGELHARD INDUSTRIES

FOR MORE INFORMATION CIRCLE 37 ON INQUIRY CARD

SYSTEMS DESIGN

AIR DATA COMPUTER

Pressure Gets Results

Air data information in flight must be obtained from the measurement of quantities that pertain to the state of the air at or near the surface of the aircraft. Aircraft instrument designers have long been looking for more accurate and more reliable instruments for measuring the available aerodynamic quantities and solving the gasdynamic equations to obtain air data in flight. M-Ten Bosch engineers believe they now have fulfilled these objectives in a modular unit consisting of three principle interconnected parts, a Mach module, altimeter module and a temperature probe.

The M-Ten Bosch air data computer is a lightweight, rugged, pressure actuated system that responds to inputs of static pressure, pitot pressure and stagnation temperature. These values are combined in electromechanical computers to furnish almost any air data desired. The pressure measuring elements deliver a high order of sensitivity as they are arranged in a compensating force balance system. The utilization of a servo system for balancing measurement forces from pressure bellows makes it possible to provide precision accuracy with the ruggedness required in an aircraft. The balancing effect maintains the bellows at constant length, thus eliminating errors due to hysteresis and variations in spring constant. The servos also provide a high power level for generation of the many functions required for air data computations.

The Mach meter module derives Mach number from the ratio of pitot pressure to static pressure (Pv/P), computes air speed and provides functions of Mach number (M) for other computations.

The altimeter module derives altitude from the absolute value of static pressure and computes vertical velocity. The temperature probe measures stagnation temperature for use in the computers.

MACH METER MODULE

M-Ten Bosch designers used Mach number, the ratio of air speed to the velocity of sound, in the computer because it is convenient to use a dimensionless quantity for computing other air data.

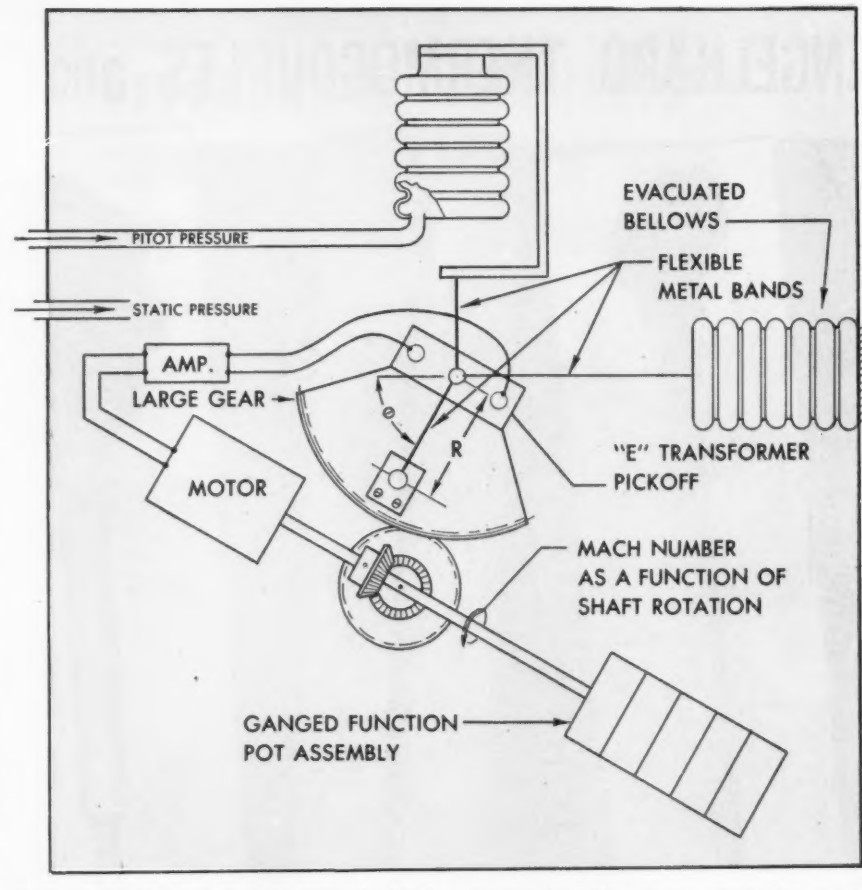


FIGURE 1. Schematic diagram of Mach meter. Two metallic bellows are used as sensing elements and are enclosed in a sealed housing. The static bellows is evacuated to essentially zero absolute pressure and sealed. A tube which is connected to the aircraft's pitot line passes through the housing to the pitot bellows while the static pressure is introduced into the housing. Three flexible bands — from the pitot bellows, from the static bellows and from a large gear—are connected to a common floating junction. The forces exerted by the two bellows upon the junction are brought into equilibrium by the correct position of the band from the gear by rotation of the large gear through the angle θ. When the system is in equilibrium, the junction is coincident with the axis of the large gear. Hence, any change in the forces exerted by the bands from the bellows, because of the static or pitot pressure changes, will displace the junction of the bands. A sensitive pick-off between the junction and the gear will detect the displacement and cause the servo motor to rotate the large gear and its band to the angle θ that will again produce the force equilibrium.

From the gasdynamic equations we find for speeds less than the velocity of sound

$$\frac{P}{Pv} = \left(1 + \frac{K-1}{2} M^2\right)^{\frac{K}{K-1}}$$

for $M < 1$

For velocities greater than the velocity of sound

$$\frac{Pv}{P} = aM^2 [b]^c \qquad \text{for } M > 1$$

where $a = \dfrac{K+1}{2}$

$$b = \frac{(K+1)^2 M^2}{4KM^2 - 2K + 2}$$

$$c = \frac{1}{K-1}$$

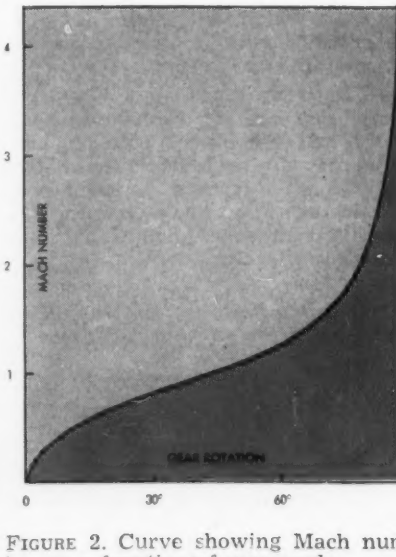


FIGURE 2. Curve showing Mach number as a function of gear angle.

Note: K = Cp/Cv = the gas constant ratio of specific heat at constant pressure to the specific heat at constant volume

Figure 1 shows how the Mach meter uses a mechanical relationship of forces resulting from pitot and static pressure inputs to compute Mach number.

The forces exerted on the junction by the bands can be expressed as

$$F_A = A_1 (Pv - P)$$

$$F_B = A_2 P$$

where A_1 and A_2 are the effective bellows areas and P and Pv are the static and pitot pressure respectively. If the areas of the bellows are equal, the relation of the forces and the angle Θ can be expressed as

$$\tan \theta = \frac{Pv - P}{P} = \frac{Pv}{P} - 1$$

Thus Mach number is a function of gear rotation (Fig. 2).

The servo motor has enough power to drive a number of function pots to obtain Mach number and various functions of Mach number for use in computing. Typical outputs are:

Mach number as a function of shaft rotation

A function for converting stagnation temperature to free air temperature

A function for determining true airspeed from stagnation temperature

A function for correcting indicated

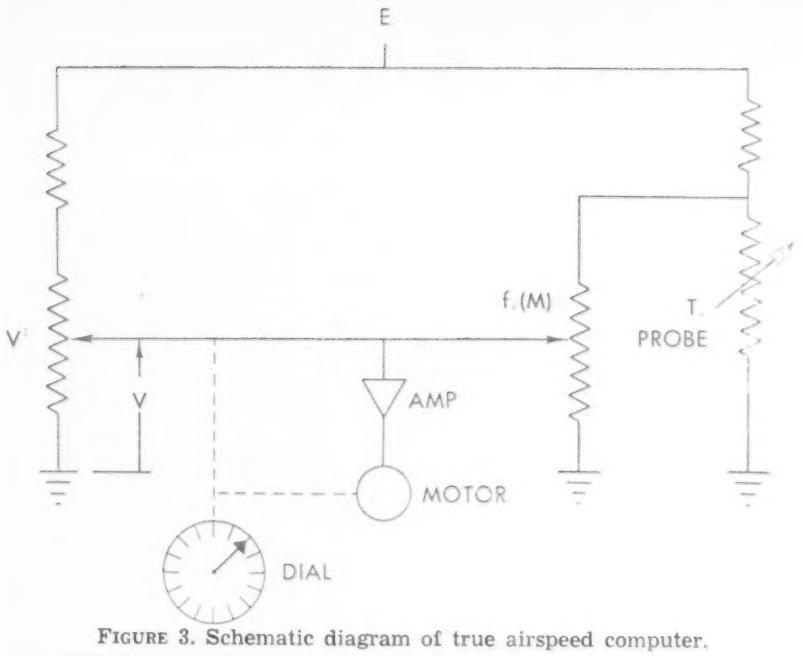


FIGURE 3. Schematic diagram of true airspeed computer.

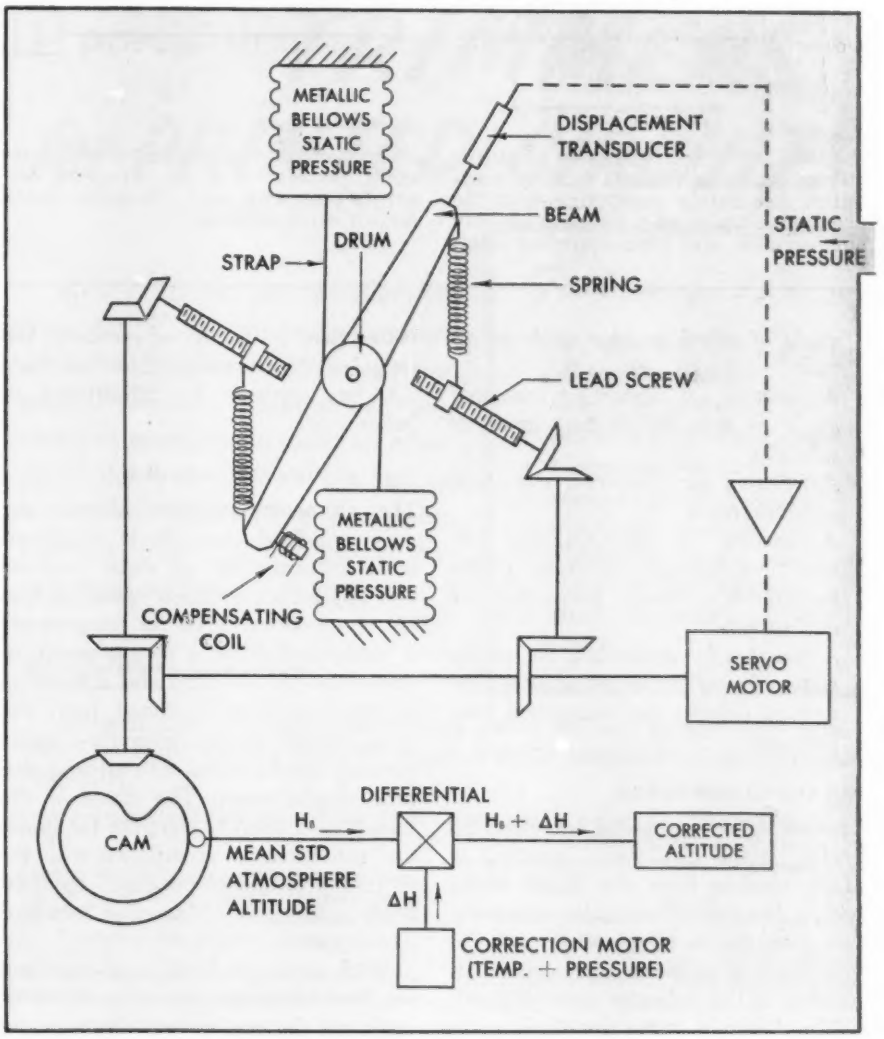


FIGURE 4. Schematic diagram of pressure sensing system in altimeter module. Two metallic bellows, evacuated to essentially zero absolute pressure, are mounted to a fixed frame. From the free ends of the bellows, straps are brought over the drum mounted upon the beam. The beam is pivoted at its center and attached at its extremities to end springs. The other ends of the springs are attached to nuts which are displaced along lead screws through the action of a servo motor controlled by a displacement transducer. The bellows and springs, together with the beam, are in the form of a force balance system sensitive to the static pressure introduced into the sealed housing. A change in the static pressure produces an unbalance in the system which permits rotation of the beam about its center. Such a rotation is detected by the transducer which causes the servo motor to reposition the nuts and the direction and magnitude of the spring forces to rebalance the system. The angle between the axis of the lead screws and the long dimension of the beam have been selected to compensate for the spring constants of the bellows and the springs so that the change of force required to rotate the beam is almost zero (astatic condition). The servo motor positions the cam which computes altitude for mean standard atmospheric conditions.

To compensate for the lag in the altitude servo system, the compensating coil receives an anticipatory signal which limits the displacement of the beam during the rise time of the servo response. This action results in a very stable system even under large values of vertical velocity.

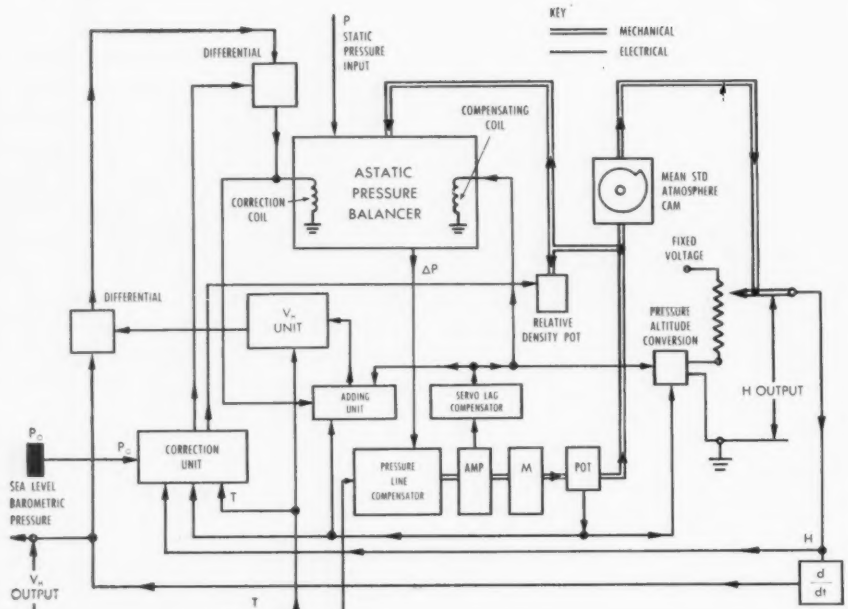


FIGURE 5. Schematic diagram of altimeter module and vertical velocity computer. Accurately computing first the pressure altitude as a function of only one variable and then applying small corrections as functions of many variables permits a small, compact, accurate unit with only one servo motor for all computations.

angle of attack to true angle of attack

A function for correcting indicated angle of side slip to true angle of side slip

A function for correcting the static pressure input

A function for computing the various air resistance corrections to the trajectories of bombs, projectiles and and rockets

A function for computing the steady state value of the angle of attack for vertical velocity and stagnation temperature

AIR SPEED COMPUTER

The air speed computer, an electrical bridge circuit, combines a function of Mach number from the Mach Meter with a function of stagnation temperature from the air temperature probe to produce true airspeed as a servo shaft rotation in the indicator unit (Fig. 3).

The designers state: the Mach meter will operate over the range from −500 to +80,000 feet and its outputs cover the Mach number range of 0 to 2; the accuracy within the range of 0.5 to 1.5 is better than 0.1%; the sensitivity of measuring static and pitot pressures is better than 0.1 inches of mercury; the range of Mach number and altitude can be increased by adjustment of bellows size.

THE ALTIMETER MODULE

The altimeter computes altitude for mean standard atmospheric conditions from measurements of static pressure and applies a correction based on free air temperature. Free air temperature is computed from a measurement of stagnation temperature and a function of Mach number obtained from the Mach meter. A cam converts a static pressure displacement into a linear altitude displacement. The curve of the cam is calculated to compute for standard conditions in accordance with the altitude-pressure-temperature relations given in the ICAO Manual of Standard Atmosphere.

With mean sea level pressure, mean sea level temperature and lapse rate as constants the cam output displacement varies with altitude.

The arrangement of the pressure sensing system, or aneroid element, is shown schematically in Fig. 4.

A correction coil in the sensing system is fed with signals to correct the output for the following departures from mean standard atmosphere:

The departure of sea level static pressure from the mean value designed in the cam.

The departure of sea level free air temperature from the mean value designed in the cam.

The departure of lapse rate of the actual atmosphere from the mean standard lapse rate.

The mean sea level pressure and temperature corrections are produced in the correction unit. (Fig. 5).In this way the servo output reflects not only the static pressure altitude but also corrections for sea level pressures and for temperature variations.

VERTICAL VELOCITY COMPUTER

Vertical velocity is a function of the rate of change of the static pressure and the altitude. With the use of free air temperature we can compute true vertical velocity.

An electrical computer combines the variables and produces vertical velocity as a shaft rotation. The manufacturer states: the altimeter module will operate in the range of −500 to +80,000 feet above sea level altitude with a sensitivity of better than 0.01 inch of mercury, and the vertical velocity computer will operate in the range of 750 ft/sec climb and 1250 ft/sec dive with an accuracy of 0.75.

WORTH FILING

Microwave Test Equipment

Six-page technical paper *Antenna Pattern Instrumentation* describes a complete microwave test equipment system for antenna pattern measurements in the frequency band from 1000 Mc/s to 10,500 Mc/s. Various components of the system are discussed in detail including transmitter, heterodyne frequency meter, and recording receiver. Paper also discusses calibration of attenuators, impedance measurement and field strength measurement.

Issued by: Polytechnic Research & Development Co., Inc., Brooklyn, New York
For your copy: Circle 140 on Inquiry Card

WORTH FILING

Subminiature Connectors

Twelve-page brochure on Continental Connector's subminiature series connectors contains specifications, outline drawings, illustrations and general information of use to the designer.

Issued by: Electronic Sales Division, DeJur-Amsco Corporation, Long Island City, New York
For your copy: Circle 143 on Inquiry Card

TEXTILE ENGINEERING

EFFI: The Eyes Over Your Wool

EFFI sounds more like somebody's sister than what it is—an electronic fiber fineness indicator—but it does have the feminine attribute of being easy on the eyes. Wherever it is introduced in the wool industry it will remove dependence on stamina of human eyes in the grading of wool. Combining analog and digital techniques with an automatic optical scanning system, EFFI measures the average diameter of 1000 wool fibers from a prepared sample and indicates the statistical distribution of the diameters in about five minutes.

BACKGROUND

Wool grading has been done largely by human eyes and brains measuring and counting fibers under a projection microscope. Grading a single sample by this method takes at least two man hours. A more rapid, less expensive, and more accurate method has long been needed to improve quality control in the industry.

Recognizing the urgency of this need, the Top Company and National Research Corporation jointly organized the Fiber Research Corporation in 1954 to develop a modern method of grading wool. Under direction of this organization, applied physicists at NRC developed EFFI.

Wool is graded commercially in terms of fiber diameters. To be able to determine the quality of a material by measuring one of its dimensions is certainly fortunate, but grading wool is not as easy as it may seem. As Dr. John Simons of National Research Corporation points out, "You can't grade a lot of wool by measuring one fiber. The diameter varies from fiber to fiber throughout the lot. Neither can you measure every fiber in a 20,000 lb. lot. So you measure a small sample, but there's bound to be a signficant random error in each measurement. You have to measure many fibers in the sample and think of statistical quantities covering the 'universe' of fibers in the lot."

Wool is classified by the United States Department of Agriculture Standards and bought and sold on the commercial market according to the average diameter of its fibers and the statistical distribution of the fiber diameters. These criteria are also the basis for achieving optimum usage in

Acetrim* sub-miniature
precision TRIMMERS
for PRINTED CIRCUITS

Here is another new development from Ace . . . sub-miniature precision wire-wound trimmers especially for printed circuits. Designed and produced to meet your tightest specifications, the new Acetrim has flat or round tabs to facilitate production assembly. Just plug into printed circuit board, secure, and dip solder.

Featuring

- ½" size
- 10 ohms to 150 K
- weight ¼ ounce
- power 2 w. @ 60° C. max.
- temperature to 125° C.
- sealed, moistureproofed, anti-fungus treated
- withstands severe shock, vibration, acceleration
- meets applicable Military specs

Ace delivers reliability

Modern mass production techniques assure delivery to meet your schedules . . . rigid quality controls assure highest standards of performance-reliability.

Acetrim — *write for Technical Data Unit #563.*

Acepot — ½" sub-miniature precision wire-wound linear potentiometers from 10 ohms to 250K. ±.3% standard. *Write for Technical Data Unit #564.*

Nonlinear Acepot — precision wire-wound nonlinear potentiometers for sine-cosine and square-law functions and other applications. High resolution, close conformity. *Write for Technical Data Unit #572.*

X-500 Acepot — ½" sub-miniature precision potentiometers for extreme temperatures of —55° C. to 150° C. 10 ohms to 250K. *Write for Technical Data Unit #571.*

*trademarks applied for

ACEPOT*
ACETRIM*

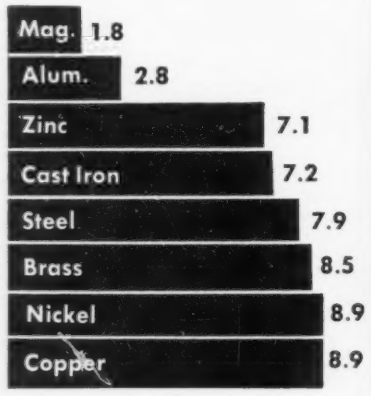
ACE ELECTRONICS ASSOCIATES, INC.

Dept. MD 101 Dover St. • Somerville 44, Massachusetts

Telephone: SOmerset 6-5130 • *Engineering Representatives in Principal Cities*

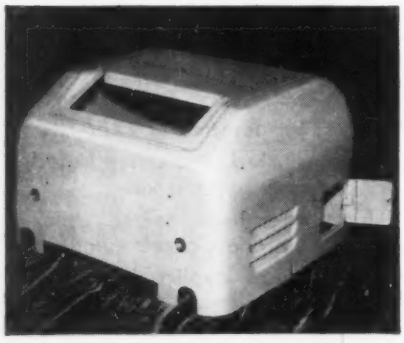
FOR MORE INFORMATION CIRCLE 38 ON INQUIRY CARD

TABLE OF COMPARATIVE WEIGHTS
(Specific Gravities)



Reducing the Weight of Assemblies?

This teleprinter cover, deep-drawn from .065" thick magnesium, weighs only 3 lbs. 13 oz. If it were made of steel, it would weigh almost 18 lbs.; or of aluminum, about 5¾ lbs.



In a wide range of products such as housings and covers, direct gauge-for-gauge substitution is often possible.

Magnesium gives you lightness plus excellent drawability.

B&P engineers will help you redesign in magnesium. B&P offers the magnesium industry's most complete facilities for fabrication and assembly. Your inquiry will bring a descriptive booklet.

BROOKS & PERKINS, INC.

1970 West Fort Street
Detroit 16, Michigan

D-1

CIRCLE 39 ON INQUIRY CARD

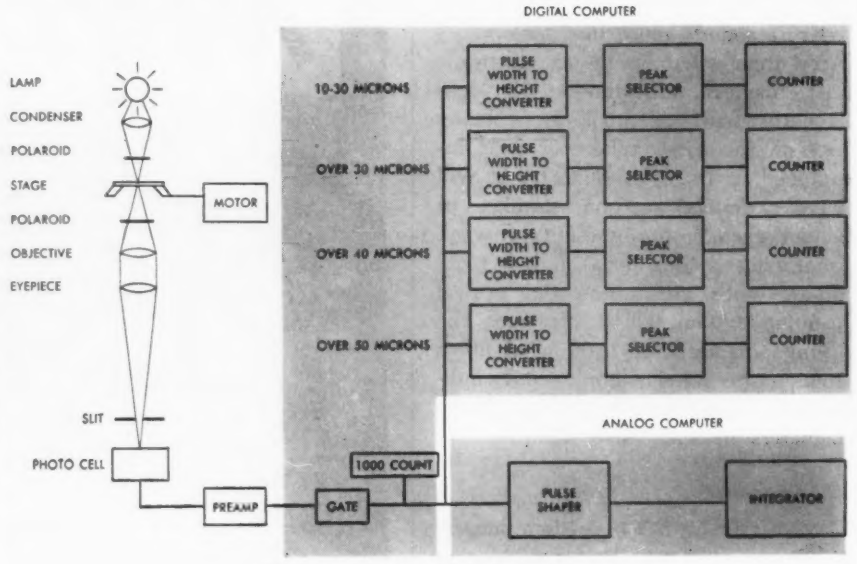


FIG. 1—EFFI Block Diagram

manufacturing operations.

EFFI's designers accepted the United States Department of Agriculture's Standards which define the industry's method of measuring the fibers optically under a projection microscope, but not without convincing themselves the approach was good.

"Looking back over the history of grading wool," said Dr. Simons, "we found that it had gone through a long development in which many difficult approaches had been tried. Present standards and techniques of the industry are good except that the method of measurement depends on human vision and judgment. After looking at hundreds of fibers through a microscope the eye begins to lose its precision and human estimation errors influence results. We decided that if we could eliminate the operator from the industry's measuring method, we would have an excellent design."

DESIGN OBJECTIVES

This decision pretty well established the design objectives. Three sub-systems would be required:

- An optical system to form images of a thousand fibers from a sample in a few minutes and convert width dimension to electrical analogs.
- An analog computer to reconvert these electrical analogs to the dimension of width accumulating their average.
- A digital computer to count the number of measurements made, indicate their statistical distribution according to the groups designated as standard by the United States Department of Agriculture, and stop the instrument at the count of 1000.

Since the industry's current method of statistical analysis was to be used, no significant change in the sampling technique was required. A group of several thousand fibers would be cut from wool top sliver to a length of about 200 microns, made parallel and transferred to a microscope slide. The slide would then be inserted in the optical system of EFFI for grading.

The design objectives have been fulfilled by NRC after three years of intensive development. Here is a description of the design and how it works.

THE OPTICAL SYSTEM

EFFI forms images of a thousand fibers in a few minutes by rapidly moving the slide through a light beam so that the beam cuts across the diameters of the fibers. This relative motion is accomplished by means of a projection microscope with a moving stage (Fig. 1).

When the slide is properly oriented on the stage and the instrument is turned on, a light beam from an incandescent lamp is focused on the slide, and the stage, driven by a synchronous motor through a precision speed reduction system, passes the slide longitudinally back and forth through the beam at a uniform speed.

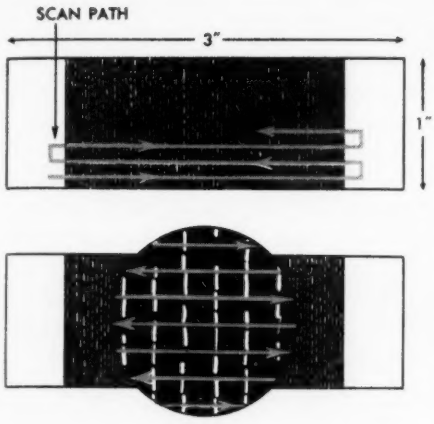


FIG. 2—Typical micro-photo of a prepared slide showing parallel fiber arrangement and scanning pattern.

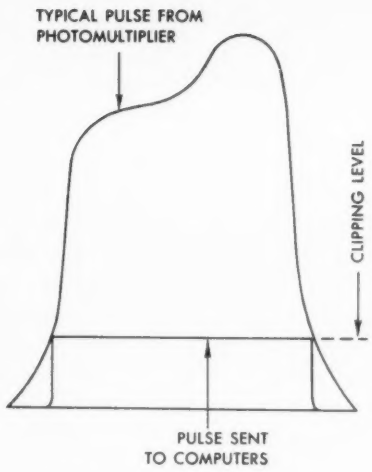


FIG. 3—Pulse Shapes

After each pass the stage indexes the slide a short distance in the transverse direction to bring new fibers into the beam on the return trip. This scanning motion and the relative orientation of the fibers is shown in Fig. 2.

As each fiber passes through the light beam, its image, magnified by the microscope, is projected onto a photomultiplier tube through a slit. This slit is narrow, relative to the fiber image, and defines or selects the portion of the image being examined at any instant.

As soon as the phototube senses the leading edge of the fiber it produces an electrical output which continues until the trailing edge of the fiber has passed (Fig. 3). The duration of this signal is an analog of the diameter of that fiber.

THE COMPUTERS

The output signals from the photocell are amplified, sent to analog and digital computers and converted into fiber diameter measurements.

In the analog computer the signals pass through a pulse shaper to obtain square waves of uniform amplitude, and then to an integrator where they are accumulated to obtain an output proportional to the summation of their duration. The system is calibrated so that when the instrument stops at the thousandth count, the indication from the integrator will be a direct measure of the average diameter of the fibers in microns.

The function of the pulse shaper is illustrated in Fig. 3. Clipping level is set as close to the baseline as possible, consistent with avoiding noise.

The digital computer counts and indicates the group distributions of the fiber measurements by means of a set of four circuits.

In each circuit the pulse durations of the phototube signals are converted to proportional pulse amplitudes and then filtered by peak amplitude selectors to allow only those pulses above a set amplitude to be counted and indicated by gas decade counters. The circuits are calibrated and set so that they count the number of fibers with diameters falling in each of the diameter groups designated in the United States Department of Agriculture Standards, one circuit being assigned to each group.

DESIGN PROBLEMS

Since the system is designed to measure fiber diameters in terms of the time a light beam traverses their diameters, the intensity of the light source and the speed of the fibers through the beam are required to be exceedingly uniform. Achieving necessary uniformity was a major problem.

Not only did the intensity of the light source vary considerably throughout the life of the bulb, but it varied measurably at the frequency of the a-c power source.

Discussing this problem Mr. Jonathan Roehrig said, "We were amazed to find that the 60 cycle power modulated the light intensity sufficiently to affect the accuracy of the system. By intuition, we had expected the thermal lag of the filament would make these variations negligible. But when we considered the pulse rate and the precision demanded of the system we realized our intuition had misled us and that the lamp had to be energized from a d-c source. We compensated for aging of the bulb by using a monitoring photocell and feedback circuits to keep the intensity constant."

Driving the microscope stage at a constant speed was no less a problem. "The best precision gears we could get," said Mr. Roehrig, "were not good enough. We found to our

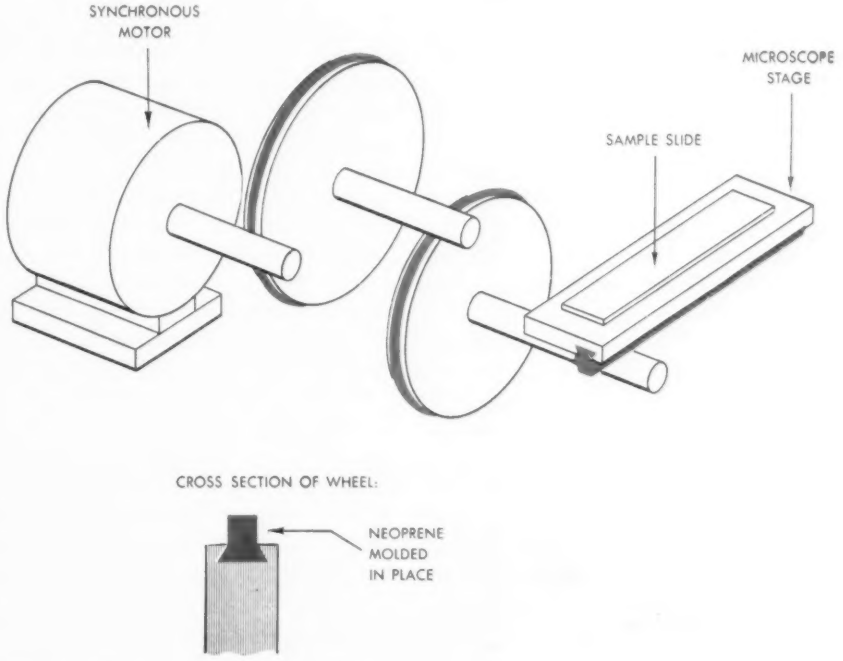


FIG. 4—Constant speed drive of microscope stage, showing friction discs.

OPERATOR PREPARES to insert sample into the optical system of EFFI. The instrument will measure the diameters of 1000 fibers in five minutes, indicating average diameter on the large meter in the center panel. Distribution by U.S. Department of Agriculture groups is recorded on counter tubes on right hand panel (nearest camera).

surprise the gear teeth caused unacceptable variations in the drive speed. In all our previous experience precision gears had been the recommended means of obtaining constant speed drives.

"Eventually we were forced to try friction wheels with neoprene rubber as the friction material (Fig. 4). At first, the performance was worse because of non-uniformities in the rubber. We got around this trouble by grinding the wheels in place, mounted in the regular bearings, to obtain very smooth surfaces. The grinding didn't affect the wheel ratios because the bearings are fixed so that the distances between them, which determine the ratios, are fixed."

TEST PROBLEMS

Like many other precision instruments EFFI was designed to be more accurate than equipment available for testing it. As a result the performance of some of the components was difficult to measure.

Illustrating this problem Mr. Roehrig said, "We had to be sure that the synchronous motor and stage drive mechanism were 'truly synchronous': that is, that we had no appreciable short term variations from the desired uniform speed. We tried many ways of measuring this, including putting reference lines on a slide as a means of calibration, but we couldn't make the margins of the lines sufficiently sharp.

"We still haven't found a satisfactory direct method to determine if the stage moves at a constant speed. Instead we find out indirectly by determining the repeatability of the overall system in measuring the same wool fibers.

"This test is done by adjusting the stage drive mechanism so that the light beam traverses the same path back and forth along the slide. If the fiber diameter distributions at the end of each pass are the same, then everything in the system is performing repeatably including the stage."

A major difficulty the designers of EFFI recognized and faced from the very beginning was that there would be no exact standard available for calibrating the instrument or evaluating its performance. They would be forced to use as a performance reference the data obtained from grading a number of wool samples by the very method EFFI was to replace.

At first this appears an impossible problem, since the probable error in a single measurement by the conventional method is greater than that of EFFI. To get sufficiently precise data, therefore, requires exhaustive testing—measurements repeated over and over again—using the conventional method. Interlaboratory tests conducted by the ASTM help in providing such data.

CURRENT PULSE GENERATOR

Programmed Pulses Test Magnetic Elements

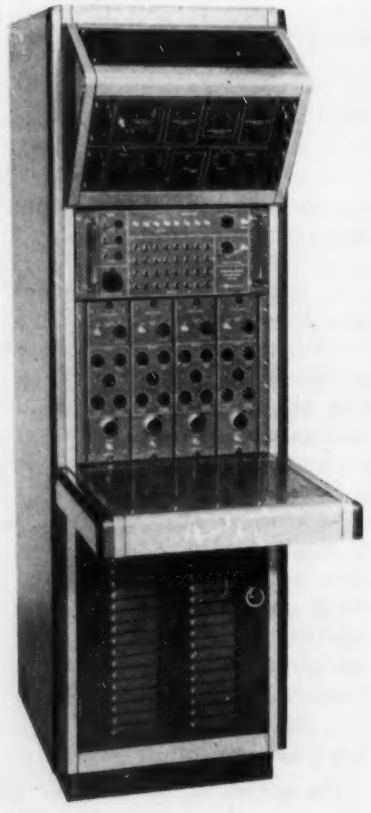
A "packaged" programmed current pulse generator provides precisely controlled, fully programmed current pulses for the research, developed and production testing of digital systems and components.

Designed by Rese Engineering, Inc., Philadelphia, Pa., the unit generates stable, high-level current pulses from a high source impedance, making it especially effective for use in analyzing inductive magnetic elements or for driving magnetic core logic systems.

Incorporated in the instrument are an extremely flexible program generator; highly stabilized, heavy-duty power supplies; two negative and two positive output current drivers. Operating at 525 volts DC, two current drivers deliver negative pluse currents to 3 amperes from source impedance as high as 20,000 ohms, while two deliver positive pulse currents to 4.5 amperes from a voltage-type source.

The design permits full control over the final current wave shape; primary or secondary pulse width is continuously adjustable from 0.5 microseconds to 50 microseconds. Linear and exponential rise time is continuously variable from 0.08 microseconds to 3 microseconds, while exponential fall time is continuously variable from 0.15 microseconds to 2 microseconds. Output amplitude is highly stabilized, remaining constant over duty-factor extremes, and at average output current levels approaching half an ampere, postive or negative.

Circle 131 on Reader Inquiry Card



Completely integrated system incorporates program generator, heavy-duty power supplies, and two negative and two positive output current drivers.

WORTH FILING

O-Ring Seals

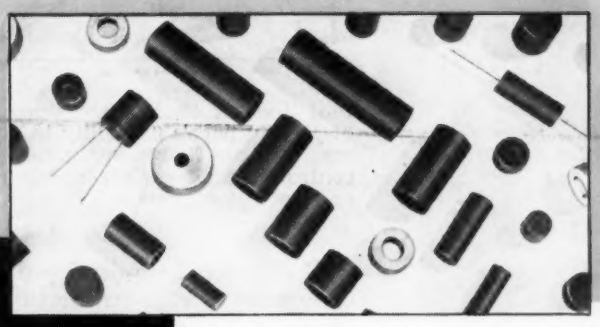
160-page O-ring handbook covers design and application of synthetic rubber O-ring seals; treats such subjects as applications, compounds, selections, engineering data, gland design, installation, static and dynamic seals, military and industrial requirements, sizes and other useful data.

Issued by: Rubber Products Division, Parker Appliance Company, Cleveland, Ohio

For your copy: Circle 147 on Inquiry Card

These Little **E - FORM** Trade Mark *Pellets Will*

REVOLUTIONIZE YOUR ENCAPSULATION PROCEDURES



The prescribed technique for encapsulating components, using "E-CASES" and "E-FORMS":

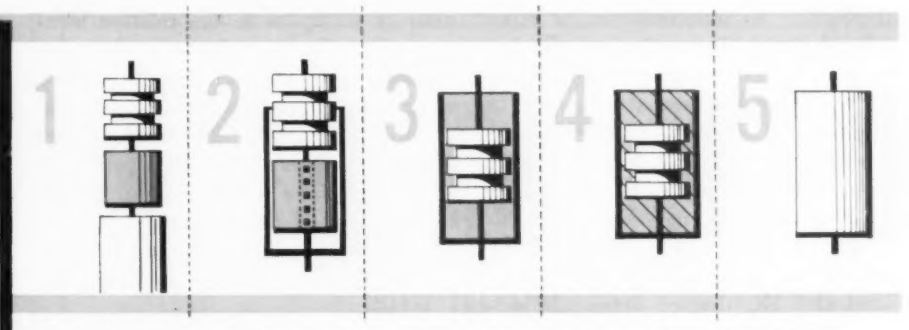
UNTIL TODAY . . .

The trouble of tedious mixing and measuring of hardener and resin, the danger of toxicity, the waste of material due to the instability of the compound . . . all of these factors combined, make epoxy encapsulation an extremely inefficient operation.

NOW . . .

A dry, stable, non-toxic pellet of preformed, premixed Epoxy compounds, tailored to your exact requirements, can make encapsulation one of the simplest operations in your manufacturing process.

Developed by Epoxy Products' experienced staff of plasticists, these pellets, though designed primarily for use in conjunction with Epoxy "E-CASE" Shells, are being widely used wherever epoxy resins are required for bonding, sealing or encapsulation.



The "E-FORM" pellet and electronic component are inserted into the "E-CASE", in that order. The assembly is then subjected to heat, with a gentle pressure exerted on the component. The heat causes the pellet to liquefy and flow around the component. Further heating gels and then cures the epoxy. The result is a completely epoxy-encased unit, resistant to humidity, temperature variations and corrosive influences.

E-FORMS eliminate:

- Wasteful mixing of hardener and resin
- Dermatitis problems (completely non-toxic)
- Dixie cups and liquid metering machines
- The need for a trained chemist to supervise operation

"E-CASES" plus "E-FORM" pellets make **mass production** and **automation techniques** feasible since these combinations can be automatically fed, positioned and assembled with the use of standard available machinery.

Pat. Appl. For

Write for complete information.

epoxy products, inc.

A DIVISION OF
JOSEPH WALDMAN & SONS
137 Coit Street, Irvington, New Jersey • Essex 5-6000

FOR MORE INFORMATION CIRCLE 40 ON INQUIRY CARD

BTU Transheat furnace with control panel moved to show safety controls and thermo-couple terminals.

Plot lines of time-temperature cycles display furnace's flexibility in delivering fast or slow temperature rises, controlled soak periods and then fast or slow quench rates.

FURNACES FOR SEMICONDUCTORS

Heat for the Cauldron

In a field growing as rapidly as that of the semi-conductor, flexibility of research and production equipment is an economic necessity. This flexibility, or adaptability to modifications, is especially desirable in continuous alloying furnaces for the production of transistors not only because of advances in the field, but also because of wide disagreement among manufacturers as to the metallurgical processes involved.

Commenting to us about this divergence of opinion, Dr. Richard Seed, Engineering Specialist in the Semi-Conductor Division of Sylvania Products, Incorporated, said: "The metallurgical processes involved in the fabrication of transistors in a continuous alloying furnace are moderately complex and not completely understood. With respect to alloying cycles, . . . , there is considerable debate and no small element of witchcraft now extant in the industry."

TEMPERATURE CONTROL

Analyzing conventional furnaces engineers at BTU Engineering Co., Somerville, Mass., concluded that the standard techniques of winding the heating coils around the muffle (the unit in which the work is processed) and sticking the temperature probe through the muffle wall into the heating chamber cannot achieve the flexibility and rapid control needed. With this arrangement the temperature probe is subjected to excessive heat at the point where it goes through the muffle wall.

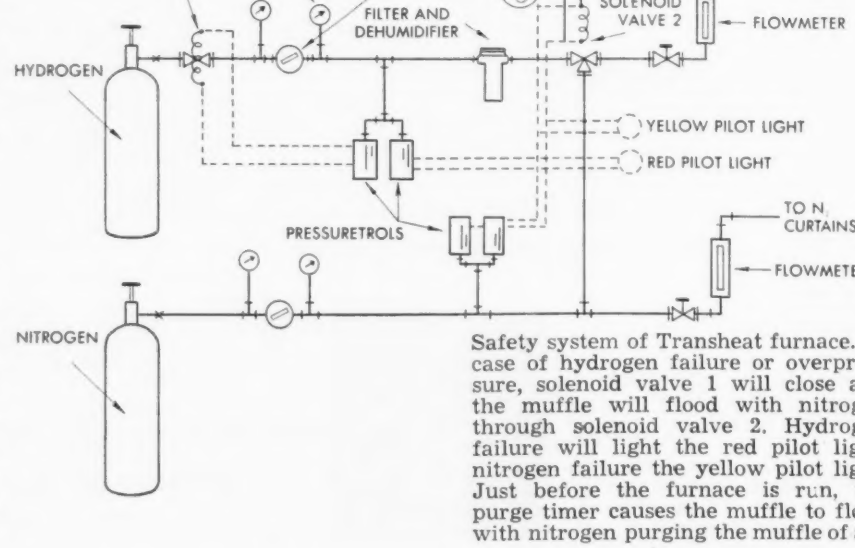
"The secret of furnace design," according to Mr. J. Howard Beck, president of BTU, "is in the relative location of the heating elements, the temperature probe and muffle. They should be arranged so that the signal pick-up comes from the muffle rather than the heaters and at the same time so that no time is lost in sensing the temperature of the heaters."

Emphasizing flexibility and fast response time as design requirements, BTU engineers have developed an entirely new furnace—new muffle, new heaters and new temperature probe—which, they claim, is very flexible and has sufficient temperature input to furnish fast rates of temperature rise and high peak temperature.

To insure flexibility of the temperature cycle, extra heating zones which can be controlled independently, were added. The above plot, showing various time temperature curves obtainable, reveals this flexibility.

ATMOSPHERE CONTROL

Improved atmosphere control was also a design requirement for the new furnaces. The designers chose a straight line furnace configuration as the most practical for continuous production of transistors. Conventional designs of this type use flame curtains to prevent the reducing atmosphere in the muffle from combining with air at the entrance and exit. Since there are no separating baf-



Safety system of Transheat furnace. In case of hydrogen failure or overpressure, solenoid valve 1 will close and the muffle will flood with nitrogen through solenoid valve 2. Hydrogen failure will light the red pilot light, nitrogen failure the yellow pilot light. Just before the furnace is run, the purge timer causes the muffle to flood with nitrogen purging the muffle of air.

fles between the reducing atmosphere and the flame curtain, there are zones at each end in which air, reducing gas, and flame are mixed. As a result, the product riding on the conveyor is subjected to heat prematurely, before it is in a fully protective atmosphere, and the product is reheated after completing the cooling portion of the cycle. In addition, the heat generated at the flame curtains affects the accuracy of the temperature control system.

Another objection to conventional designs is that they introduce the reducing atmosphere at room temperature into the furnace causing cool spots at the points of entry.

But BTU Transheat furnace overcame these difficulties by an entirely new muffle design. Flame curtains were replaced by nitrogen curtains at each end of the muffle separated from the reducing gas by baffles.

The nitrogen is fed into the curtained area from both top and bottom with sufficient flow to overcome any possible effect of eddy currents caused by the movement of the conveyor belt or product, which tend to bring air into the muffle.

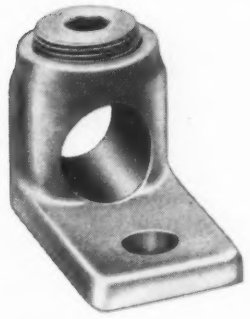
To prevent introducing the reducing atmosphere directly into the heating chamber, BTU engineers designed the muffle so that the gas is preheated. The preheated gas is diffused into the heating chamber in proportion to its specific volume.

The reducing atmosphere is drawn out of the muffle through vertical funnels and tubes at the border planes between the hydrogen and nitrogen, and is burned outside the furnace. This arrangement has the advantage of preventing an atmosphere flow pattern tending to draw air into the furnace, by creating a back pressure against the nitrogen curtain.

SAFETY SYSTEM

A safety system to protect against aberrations or interruptions in the normal supply of reducing atmosphere or nitrogen, especially against excess pressure of the reducing atmosphere, is important not only in avoiding danger, but in maintaining consistent atmosphere control. The safety system in the BTU furnace shuts off the supply of ambient gas when its pressure is excessive and floods the muffle with nitrogen. It also produces a visual or audible signal whenever the pressure of ambient gas is excesive or insufficient.

Sherman Lugs



Sherman Solderless SS Type "All-Around" lugs are made in six sizes – #14 to 1000 MCM. Large contact surface for maximum conductivity. Open end barrel assures proper cable installation. Low silhouette – easy to install in tight places. Precision made and corrosion resistant.

Sherman – Known for quality since 1895.

H. B. SHERMAN MANUFACTURING CO.
BATTLE CREEK, MICHIGAN

FOR MORE INFORMATION CIRCLE 41 ON INQUIRY CARD

Do You Need...
POSITIVE DRIVE DURING NORMAL OPERATION?
POSITIVE LOCK IN ANGULAR POSITION AT POWER CUT-OFF?
YOU GET BOTH
WITH THE MORTON

Power Source — SMITH-NOBAK DEVICE — Driven Load

The Smith-Nobak Device permits both shafts to rotate simultaneously. When power stops, the device prevents further rotation of the mechanism either from the initial inertia force or from an external force applied from anywhere except the original source. The driven shaft is locked in position to prevent its rotation in either direction. Application of power unlocks the device instantly.

The device is finding numerous uses in automation, aircraft control mechanisms, hoists, transfer tables, conveyors, punch presses, printing presses, and wherever a positive control of angular position is required. It is especially adaptable for steering mechanisms of industrial trucks, tractors, and boats; for feeds into presses, and for boom hoists of derricks. Load ratings from 50# in. to 2600# in. are available. Specific recommendation will be sent you on receipt of your requirement.

4-page Smith-Nobak bulletin and technical data available on request. We also manufacture special ball, roller and thrust bearings to meet customer requirements. Thrust bearing catalog available on request.

MORTON BEARING COMPANY 815 WILDT STREET, ANN ARBOR, MICHIGAN

FOR MORE INFORMATION CIRCLE 42 ON INQUIRY CARD

SYSTEMS DESIGN

DIGITAL READOUT PRINTER

Solenoid-Lever design converts voltage pulse to lateral motion

Relays and stepping switches perform the transition from electrical current to mechanical motion so well that many designers instinctively turn to such an arrangement to produce lateral motion from a series of electrical pulses. Yet, in many cases relays and moving-contact switches cause reliability and maintenance problems.

Taking a new approach, Computer Measurements Corporation uses a modular solenoid-lever device (Fig. 1) as the electromechanical transducer in the design of a digital readout printer. This mechanism, described for us by Mr. Rex Lovejoy, Director of Research at CMC, provides lateral motion proportional to coded electrical signals which are applied as voltage pulses into the digital printer from auxiliary equipment.

A digital readout printer is an electromechanical device that turns out a printed record of digital numerals on paper as a result of being energized with coded electrical pulses. Printers of this nature are used in such places as electronic circuit laboratories to monitor and test the behavior of oscillators, to count time between closely spaced electrical phenomena, to count particles passing a given point over a period of time, to measure voltages and current frequencies and record a series of such meter readings and generally in many applications where measurements of time periods are involved. Such a printer is usually used in conjunction with an electronic frequency counter instrument.

ACCURACY IN ELECTRONIC COUNTERS

Most electronic frequency counters display their meter readings as lighted digital numerals on a front display panel. An observer can read the frequency or time period of electrical signals being monitored as often as he chooses, by either pressing a button each time he wants to read or presetting the electronic counter to cycle itself and automatically display readings a given number of readings per minute.

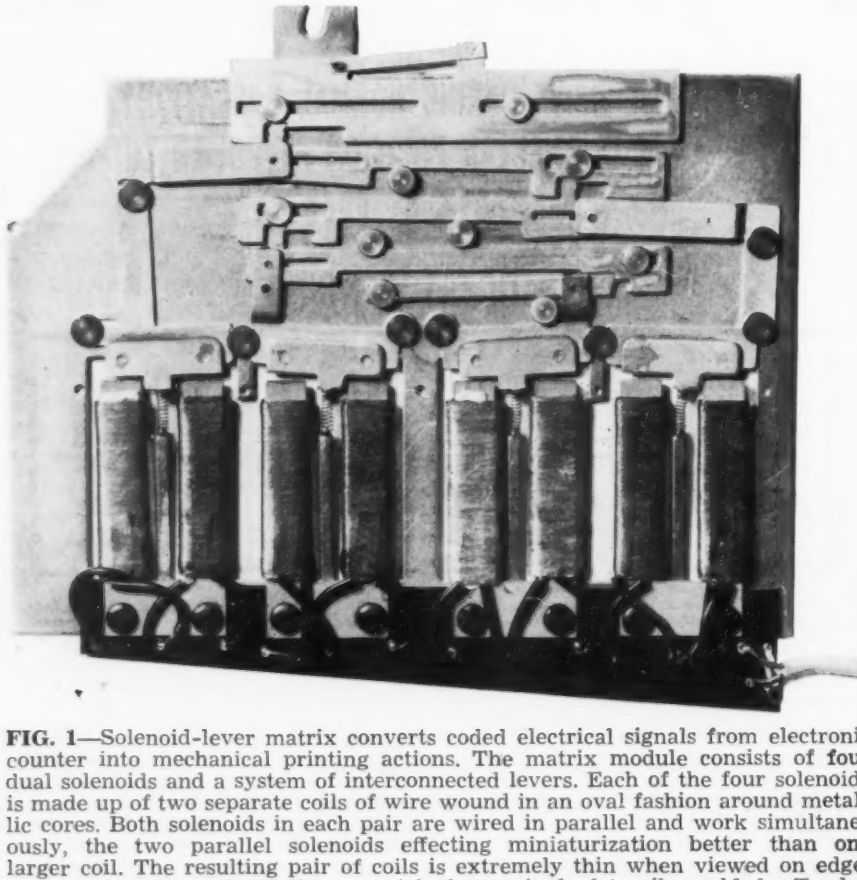


FIG. 1—Solenoid-lever matrix converts coded electrical signals from electronic counter into mechanical printing actions. The matrix module consists of four dual solenoids and a system of interconnected levers. Each of the four solenoids is made up of two separate coils of wire wound in an oval fashion around metallic cores. Both solenoids in each pair are wired in parallel and work simultaneously, the two parallel solenoids effecting miniaturization better than one larger coil. The resulting pair of coils is extremely thin when viewed on edge; and yet, the thin pair do the same job that a single fat coil would do. Twelve such modules are positioned side by side in the printer shown to create 12 printed digits simultaneously.

FIG. 2—Computer Measurements Corporation's Digital Readout Printer.

A digital frequency counter provides precise measurements of frequency and is inherently quite accurate. Frequency or time period readings can be obtained to any desired number of significant figures or decimal places within the capabilities of a given machine and can be made as slowly or as rapidly as the need dictates. If a permanent record of counter readings is desired, an observer can set the counter to cycle itself just as rapidly as he can jot down the readings on the panel.

Still there is a big disadvantage to writing down readings by hand; the electronic counter is capable of providing readings much more rapidly than a man can write. So it was logical that machines be developed to print out the rapid meter readings of such an electronic counter as well as of similar instruments. The digital readout printer shown in Fig. 2 is such a device.

ADDING MACHINE MECHANISM USED

The speed with which a readout printer can produce printed materials is a function of several factors. First, the electrical information generated by the electronic counter must be converted into a form suitable for transformation into mechanical motion. Then the mechanical motion must be used to position type against paper, if we assume that conventional letterpress printing is to be used. Since standard off-the-shelf adding machine mechanisms provide a dependable vehicle for printing the numerals on paper, designers have turned to adding machine sub-assemblies for the final step in providing readout printing. Such off-the-shelf mechanisms print about four lines per second dependably, each line containing 12 digits.

The design problem in developing a printer is to convert the coded elec-

trical pulses from an electronic counter into mechanical printing actions. The unique solenoid-lever matrix (Fig. 1) was developed to do this job of electromechanical transducing. The matrix is so named because it is a logical orderly arrangement of units which will respond proportionally to produce an accurate translatory action when energized with input electrical information.

HOW THE MATRIX WORKS

The matrix module which translates a group of electrical impulses of very short duration into a printing bar position operates in the following manner. Each time a coded electrical signal is fed into the solenoid-lever system a numeral is represented. The number system is shown in the table of Fig. 3.

		PERMUTED BINARY CODE			
		1	2	3	4
DECIMAL NUMBERS	0	0	0	0	0
	1	1	0	0	0
	2	0	1	0	0
	3	1	1	0	0
	4	0	1	1	0
	5	1	1	1	0
	6	0	0	1	1
	7	1	0	1	1
	8	0	1	1	1
	9	1	1	1	1

FIG. 3—Coding scheme. Conversion of four-digit electrical code information into ten-digit decimal printed numbers. For example, if the number 4 is to be printed, solenoids 1 and 4 would not be energized but solenoids 2 and 3 would be energized. This code, used by most electronic counters, differs from an ordinary binary code.

Assume that the number 4 is to be printed on the paper tape that comes out the top of the printer. Solenoids 1 and 4 would not be energized but the two middle solenoids would. The signal to energize the two middle solenoids is applied to the matrix for approximately 150 milliseconds. During this time the two mechanical levers immediately adjacent to the armatures (cores) of the two middle solenoids (Fig. 1) are attracted to the electromagnetic cores and latch themselves into place mechanically. Then a bar, at right angles to the plane of the lever arms, which rides in the slotted tab at the bottom of the assembly (Fig. 1) is moved by a motor. The bar attempts to move the slotted tab all the way to the right hand side of the module, but is stopped four-ninths of the way across by the lever system. The result then is that the numeral 4 is pushed up toward the paper tape in the machine and held there while a force is applied by the adding machine mechanism to imprint the 4 on the paper tape.

The printing bar is actuated by a "print" command as often as four times per second. Each time the printing bar is actuated, it attempts to travel all the way to the numeral 9 position. However, depending upon the arrangement of the levers in the matrix, the bar is stopped along the way at any position from zero to the numeral 9. Immediately after any numeral is printed upon the paper tape, the printing bar is mechanically reset in its zero or home base position.

One of the design features of the module enabling the printer to operate at high speed is that a new set of electrical signals can be imposed while the printing impression is taking place. As the printing bar travels, and even after the solenoids are energized and their arms are latched into place, electrical signals can be changed at will in the four dual solenoids without affecting the numeral positioning. Although these signals can be changed in a few milliseconds, the operation rate of the printer as a whole is limited by the speed the adding machine mechanism can push the printing bar forward and apply printing pressure to the numerals in front of the paper tape.

THE ELECTRONIC CIRCUIT

These plug-in modules constitute the heart of the digital printer. However they are useless without proper electrical signal inputs. Electronic frequency counters supplying those inputs usually have electrical output receptacles containing four electrical contacts for each digit which the counter shows on its front panel. With 12 digits displayed, 48 wires, plus a common ground connection, will normally appear at the counter readout electrical receptacle. In addition a connection is available for an electrical signal—a pulse representing a "print" command. Usually a connection is also brought out to enable auxiliary equipment such as a digital readout printer to electrically by-pass the reset circuit of the counter itself. The by-pass wiring prevents a re-cycle of the frequency counter until the readout printer has completed the printing of one line of digits.

Using such normally-available wiring connections, the readout printer serves a two-fold purpose electronically. First, it decipers the code signals, represented in a 1-2-2-4 fashion as illustrated by Fig. 3, into a decimal numeral system. This action is accomplished by the matrix module described above. Second, the printer amplifies the power of the output code signals of the counter to a strength sufficient to operate the mechanical printing mechanisms. In accomplishing these functions, the printer circuitry must be designed so that absolute accuracy is assured.

Figure 4 is a block diagram of the printer showing how the basic electronic system is designed. Each code signal from the counter is amplified in a pentode to provide sufficient current to energize a dual solenoid in a matrix module. Since the coded data signals themselves are in the nature of off-on

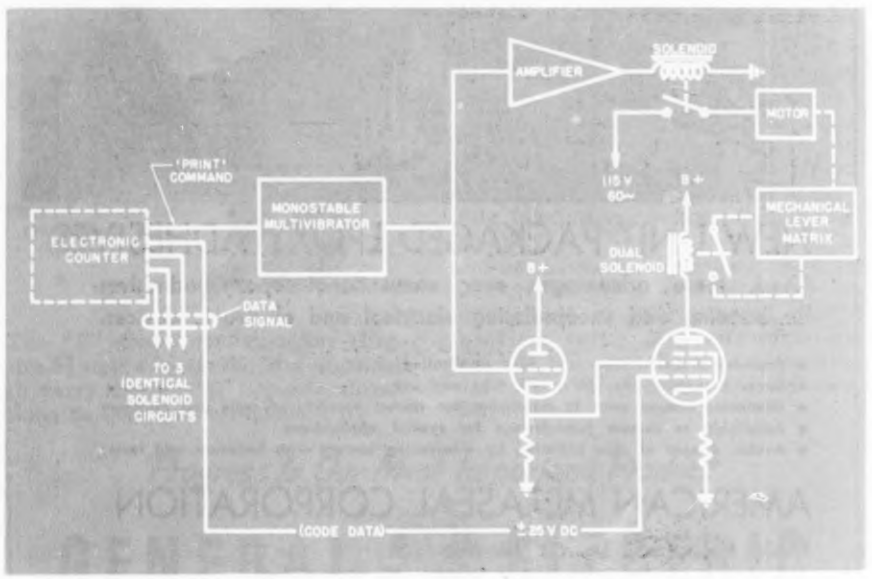


FIG. 4—Block Diagram of digital readout printer.

signals, amplitude distortions and broad gain changes in each pentode amplifier do not affect the circuit operation. Either the tube is conducting fully or cut off by the input code signal. More than enough current is furnished by each tube in its poorest rated operation condition to energize the matrix solenoid.

During the "off" periods of each vacuum tube, the tube characteristics are unrelated to the operation of the other circuits. The code signals into the printer from the counter are more than sufficient in amplitude to bias the tube in each case to either full cut-off or conduction. In addition to the code signal (data signal) applied to the control grid of each pentode, the screen grid of the pentode is controlled. During and the screen grid energized with a positive voltage. This means that, except when a "print" command is applied, the polarity and magnitude of any voltage on the control grid of the pentode does not affect the current in the matrix solenoid.

The "print" command from the counter is used to trigger a monostable multivibrator in the readout printer. The monostable, or one-shot, multivibrator provides an output pulse of positive voltage to the pentode screen grid for a very short time (100 to 200 milliseconds). This allows the pentode to conduct only during a gated time period. If the signal on the control grid is positive during this gated time period, the pentode will conduct current energizing the solenoid. If, on the other hand, the signal on the pentode control grid is negative during the gated time period, the pentode will not conduct current. Thus, regardless of stray voltages during cycling periods of the counter, the matrix module is energized only when the counter gives a "print" command or when the manual override button is pressed.

POWER SUPPLY

Since the printing circuitry operates in a gated fashion as described, the power supply furnishing plate current to the pentodes is never called upon to deliver its maximum output continuously. With such a low duty cycle, the B+ supply can be designed to furnish peak currents only during short periods. A storage capacitor of 40 microfarads at the output of the power supply stores electrical energy during "off" portions of the duty cycle. In addition, separate plate supply voltages are used in the printer shown. One supply potential operates the string of multivibrators as is shown in the block diagram. An isolation, or decoupling, filter separates the multivibrator plates from the plates of the pentodes. The filter completely prevents stray switching signals of the flipflop circuits from interfering with the currents in the matrix solenoids. The use of these filters, plus conservative design in the pentode solenoid-energizing circuits, allows use of an unregulated power supply. The power supply, a transformer and two silicon cartridge rectifiers, is extremely simple and straightforward.

Circle 164 on Reader Inquiry Card.

NOW SIMPLY MIX AND FIX WITH . . . . . **FIX-MIX**

NEW UNIT PACKAGED EPOXY ADHESIVES

Check these advantages over conventional epoxy adhesives for bonding and encapsulating electrical and electronic devices.

- Provides a quick, sure, and easy application
- Saves time—just mix within the tube and use
- Eliminates human error in measuring out correct amounts of resin and hardener
- Adaptable to custom formulations for special applications
- Avoids danger of skin irritation by eliminating contact with hardener and resins

AMERICAN METASEAL CORPORATION

18666 Fitzpatrick, Detroit 28, Michigan
607 65th Street, West New York, N. J.

FOR MORE INFORMATION CIRCLE 100 ON INQUIRY CARD

NEW DYNAMOMETER CONTROL

Electrically-Simulated Inertia

Electrically-simulated inertia has been substituted for unwieldy inertia discs (flywheels) in a new type of dynamometer control.

Use of simulated inertia eliminates the necessity for hoisting huge flywheels into place for the testing of acceleration and deceleration performance of passenger cars, trucks, and buses. Formerly, as many as 24 huge flywheels weighing a total of about 10 tons were required in the testing of heavy truck chassis.

The flywheels were used to simulate the effect of vehicle mass.

Engineers say the new control provides savings in floor space, initial cost, and time required to set up for a test. Using electrical simulation, it is necessary only to set a potentiometer for the desired inertia value and put the test stand into operation.

Engineers at General Electric's Industry Control Dep't., Roanoke, Va., who developed the technique, say that several applications of electrically-simulated inertia control are now being studied.

Circle 250 on Reader Inquiry Card.

New trends and developments in designing electrical products . . .

How to magnetize permanent magnets to obtain maximum energy product and magnetic stability

According to the domain theory of ferromagnetism, a magnetic material is composed of elementary magnetic volumes called domains. These domains are randomly oriented in unmagnetized materials (Figure 1). Their fields cancel each other, and no external field results.

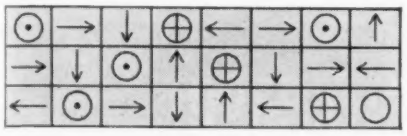


Figure 1—Demagnetized material (domains completely disorganized)

Subjecting the magnetic material to an external field rotates the elementary magnets in the direction of the applied field (Figure 2). In permanent magnets, this orientation is retained to some extent after the field is removed. The magnetic material exhibits poles and an external field.

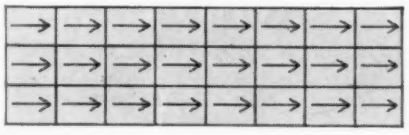


Figure 2—Magnetized material (domains rotated into alignment)

The improvement of permanent-magnet materials has made the elementary domains more difficult to align. Proper magnetization techniques have thus become highly important because of the adverse results of partially magnetized magnets.

Partial magnetization means that the full external field capabilities of the magnet are not realized. And, the magnet is less resistant to demagnetizing influences – hence less stable.

Consequently, General Electric has done extensive work with users of permanent magnets on the problems of effective magnetization.

Modern magnetizing equipment takes advantage of the fact that magnetization is essentially an instantaneous process, and may be achieved with short-duration current impulses. Consequently, direct-current equipment, like generators and electromagnets, are giving way to impulse equipment.

The main advantages of impulse-type magnetizers are lower equipment cost, reduced demand on power supply, and greater flexibility in shapes of fields that can be set up. Impulse equipment generally falls into two basic types:

(1) Half-cycle type, operating from A.C. line (Figure 3). Here, an ignitron tube with suitable control allows current to flow for one-half cycle.

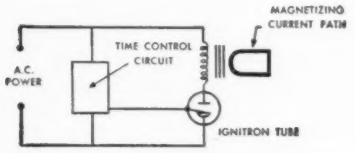


Figure 3—Circuit for half-cycle-type magnetizer

(2) Energy-storage type (Figure 4). Here, a capacitor is charged at a relatively slow rate, and then discharged into the magnetizing circuit. This type of equipment is extremely versatile; tremendous peak currents are possible from low-capacity power systems.

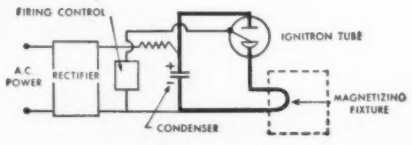
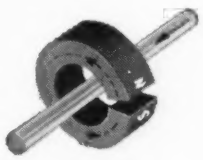


Figure 4—Circuit for energy-storage-type magnetizer

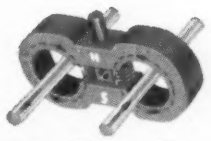
Using this equipment, a simple magnet shape like the "C" magnet in Figure 5 can be magnetized by a single conductor threading the magnet.

Figure 5—Conductor arrangement for "C" magnet



The "E" shape configuration (Figure 6) uses two conductors arranged to carry current in opposite directions to achieve correct polarity.

Figure 6—Conductor arrangement for "E" magnet



Multi-pole magnets (Figure 7) require alternate conductors carrying current in opposite directions to establish simultaneous magnetization of all poles.

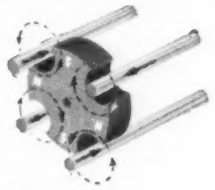


Figure 7—Conductor arrangement for multi-pole magnet

One of the more recent developments in magnet configurations – the "bowl" magnet – can be magnetized radially by the conductor arrangement in Figure 8.

Figure 8—Conductor arrangement for "bowl" magnet

These examples give some idea of the variety of magnetizing problems encountered by users of permanent magnets. Each configuration represents a distinct engineering problem in which such variables as conductor size, conductor arrangement, peak current, and current duration must be accurately balanced.

General Electric magnet engineers have at their fingertips all the knowledge and techniques requisite for efficient magnetization. They are always ready to assist designers and users of permanent magnets in getting maximum-energy product and stability.

For more information on G-E Alnico magnets, or assistance on any phase of your magnet design problem, write *Magnetic Materials Section, General Electric Company, 7818 North Neff Boulevard, Edmore, Michigan.*

Progress Is Our Most Important Product

GENERAL ELECTRIC

FOR MORE INFORMATION CIRCLE 44 ON INQUIRY CARD

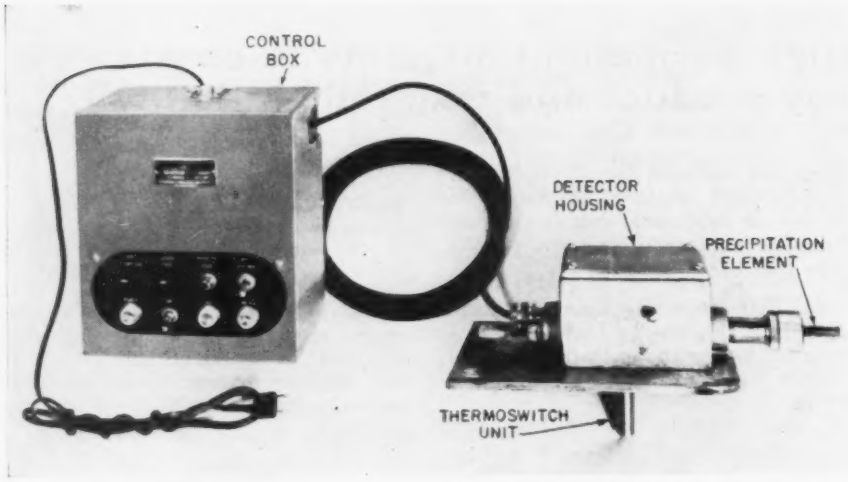


FIG. 1—Complete ice-alarm system using a two-element detection unit to sense atmospheric icing conditions.

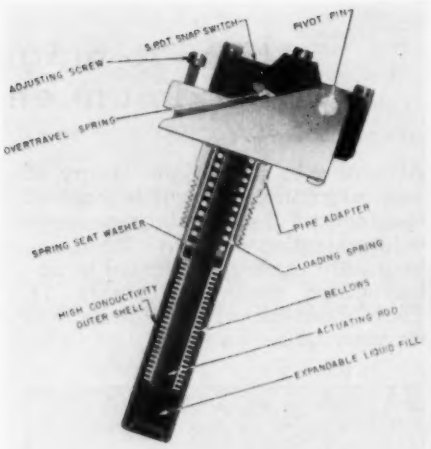


FIG. 2—Cut-away of the Fenwal snap-action Thermoswitch unit which provides the temperature sensing part of the detection unit.

PREVENTIVE ENGINEERING

De-icer Detects Symptoms Of Impending Ice Formation

A new sleet-and-ice alarm system, designed to diagnose and warn of atmospheric icing conditions, has been developed by the American Instrument Co., Inc. A specially-developed precipitation monitor and a Fenwal snap-action Thermoswitch sense the two atmospheric conditions, precipitation and low temperature, which tend to form ice when they occur together. In responding before ice actually forms, the system differs from existing ice-alarm systems such as the venturi type or strain-gage type which are responsive only to ice formation. The advance warning allows necessary precaution and also reduces power consumption of heaters coping with already deposited ice.

HOW THE SYSTEM WORKS

The system consists of the detection unit and the control box and associated alarm devices. The two sensing elements in the detection unit are connected in series so that the alarm remains inoperative unless both atmospheric conditions necessary for ice formation are present. When the alarm circuit actuates, a SPDT relay switches off the "no-ice" indicator light on the control box, energizes the "ice" indicator light and sounds the alarm bell. The alarm circuit will also turn on the heaters if desired. As soon as the icing conditions pass, the system clears itself automatically.

THE DETECTION UNIT

The precipitation detector has two parallel coils of fine Nichrome wire wound around the outside of a plastic coil form. A drop of water on the detector provides sufficient conductivity to short out the windings and complete the circuit to ground (provided the contacts of interlocking thermostat are closed). Inside the tubular coil form, a potted 2.8 watt 6-volt heater operates continuously while the system is in use. This heater changes any snow or sleet falling on the detector to water so that the element will be equally responsive to all types of precipitation and also accelerates drying enabling the system to clear itself quickly when precipitation stops.

The Fenwal Thermoswitch (Fig. 2) was selected for three reasons. First, it can withstand the wide climatic varia-

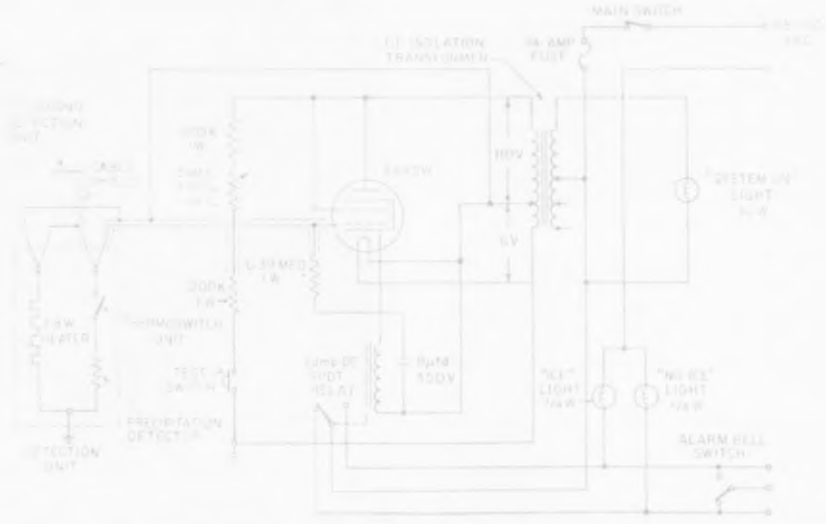


FIG. 3—Circuit diagram of the ice alarm system. Control unit, operated on a 125-volt ac supply, contains a cathode-follower amplifier and an associated alarm circuit. Amplifier and detection units are powered through a 1:1 isolation transformer, with the 2.8 watt heater supplied from the 6-volt tap of the transformer through the cable shield. Combination of closed thermostat contacts and shorted windings of the precipitation element develops a small voltage between the grid and the ground. This produces a sufficient current change through the cathode follower and its biasing resistor to actuate the 1-amp dc relay of the alarm circuit.

Amplifier circuit contains a 5-megohm variable resistor enabling adjustment of the threshold sensitivity of the unit to compensate for resistance changes on the precipitation element windings from accumulated dirt. The test switch checks the amplifier and alarm circuits.

PRECIOUS METAL CONTACTS PROVIDE LONG OPERATING LIFE AND UNVARYING PERFORMANCE

Progressive research development policies, coupled with vast experience in related fields, enable BAKER to apply its know-how in precious metals to meet the diverse problems accompanying the selection of precious metal contacts to suit individual requirements. The following BAKER precious metal materials serve to illustrate what BAKER's research departments make available in SILVER, PLATINUM, PALLADIUM and GOLD, in pure or alloy form, for supply as wire, rod, sheet, and as fabricated forms, such as rivets, discs, solderbacks, welding types, overlay, edgelay, inlay and irregular shapes.

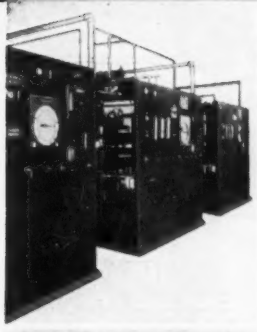
SILVER AND SILVER ALLOYS

One of the most widely used materials for electrical contacts, SILVER provides high resistance to atmospheric corrosion. Silver Alloys—which contain base metals to achieve specific properties—provide other modified characteristics, such as increased resistance to arc erosion, sticking and metal transfer.

PLATINUM AND PLATINUM ALLOYS

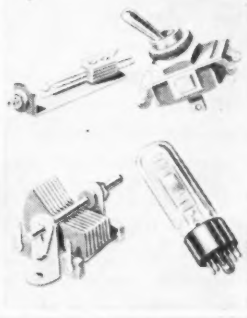
Offering a higher resistance to tarnish and corrosion than any other contact material, the contact resistance of platinum can be maintained at a low value throughout its operating life. Platinum alloys provide higher melting points and hardness, greater resistance to deformation, longer life and increased resistance to sticking and metal transfer.

Write for complete catalog material and details.



NITRONEAL® GAS GENERATOR economically and safely provides fully automatic furnace brazing and bright annealing of stainless steel.

FINE WIRE of ductile and non-ductile material meets the expanding requirements of industry with highest quality.



RHODIUM PLATING provides a hard, brilliant white, non-tarnishable surface extremely resistant to corrosive conditions.

BAKER PRECIOUS METALS

BAKER & CO., INC.

113 ASTOR STREET, NEWARK 2, NEW JERSEY

NEW YORK • SAN FRANCISCO • LOS ANGELES • CHICAGO

ENGELHARD INDUSTRIES

RESEARCH MAINTAINS BAKER'S LEADERSHIP IN PRECIOUS METALS

FOR MORE INFORMATION CIRCLE 45 ON INQUIRY CARD

tions of the far north since it can be exposed indefinitely to −100°F and to well above 125°F and still operate precisely at its setpoint temperature.

Second, a direct and constant relationship between angular rotation of the temperature setting screw and the amount of adjustment in setpoint temperature (one full turn = 23°F) made it possible to equip the thermostat with a direct-reading temperature dial and pointer. Thus, the unit can be set in the field without reference to a calibration table—more than a casual convenience to a tower man at the top of a 400-ft. antenna.

Third, the compact head of the unit permits installation, even with the added dial and pointer, in the detection-unit housing where clearance is limited.

EQUIPMENT LAYOUT

Each control box may be connected to one or two detection units wired in parallel. The detection units may be placed up to 1000 feet away from the control box using RG-69/U cable, and 2000 feet away using RG-62/U cable. The housing of the detection unit is fully moisture-proofed by a gasket in the cover and by gasketing in the bushings where the thermoswitch unit and precipitating element are threaded into the housing.

Approximately 100 of these systems have been furnished for protecting radar towers on the DEW line and Project Alice. The reduction of antenna heat requirements is an important economy in remote northern areas where all supplies, including the fuel to operate power generators, must be flown in during the few good months of good flying weather.

Besides radar tower applications, these systems can be used to detect incipient icing conditions around airports, buildings, highways and other locations where advance warning of icing would provide valuable operational guidance.

Circle 162 on Reader Inquiry Card.

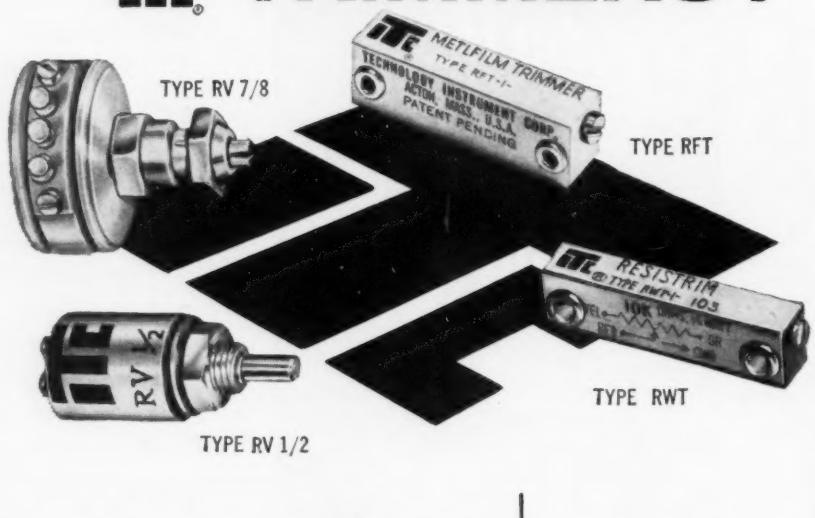
WORTH FILING

Terminals

Extensive engineering and design information on Teflon-insulated terminals is provided by the latest "Press-Fit" Manual distributed at the Wescon Show for the first time.

Issued by: Sealectro Corporation, Mamaroneck, New York
For your copy: Circle 146 on Inquiry Card

WHY TRIMMERS?



TYPE RV 1/2

TIC, originator of trimmer pots, combines advanced design techniques and craftsmanship in its miniature and subminiature precision trimmer potentiometers. Pot size ranges from ⅓ inch to ⅞ inch . . . power ranges up to 4 watts.

TIC pots provide the ultimate in:

- Long Term Reliability by use of precious metal contacts, low temperature coefficient of resistance
- Sealing Design Techniques provide protection against moisture and salt spray
- Rugged Construction for resistance to shock and vibration
- Flexibility of Design Applications, a variety of shapes for optimum space use
- High Resolution

TYPE	TURNS	RESIST. RANGE	TEMP. RANGE
RFT*	25 metallic film	50 — 25K ohms	−55° to +125°C
RWT	1 wire wound	50 — 15K ohms	−55° to +95°C
RV 1/2	1 wire wound	50 — 100K ohms	−55° to +145°C
RV 7/8	1 wire wound	100 — 100K ohms	−55° to +145°C

*Optimum spacing — as many as 7 in area of 1 sq. in.

All designed for the most stringent aircraft and rocket applications.

All units are available from stock in production quantities.

Complete information on request.

These advanced design features provide for wide applications:

- Threshold voltage adjustment
- Fixed gain adjustment
- Parameter compensation
- Critical magnetic and electric bias
- Establishing circuit values
- Padding
- Balancing adjustments
- Adjusting scale factors

TECHNOLOGY INSTRUMENT CORP.

529 Main Street, Acton, Mass. COlonial 3-7711

FOR MORE INFORMATION CIRCLE 46 ON INQUIRY CARD.

TESTS PROVE—RELIABILITY IMPROVED MOST WITH ATLEE COMPONENT HOLDERS!

Impartial evaluation tests by one of the world's leading aviation firms now substantiates the fact that ATLEE COMPONENT HOLDERS provide *automatic increase in holding power* under extreme vibration and temperature changes.

THE TESTS: 100 insertion-withdrawals; 2000 cps at 65 G's; and 200 G's axial impact.

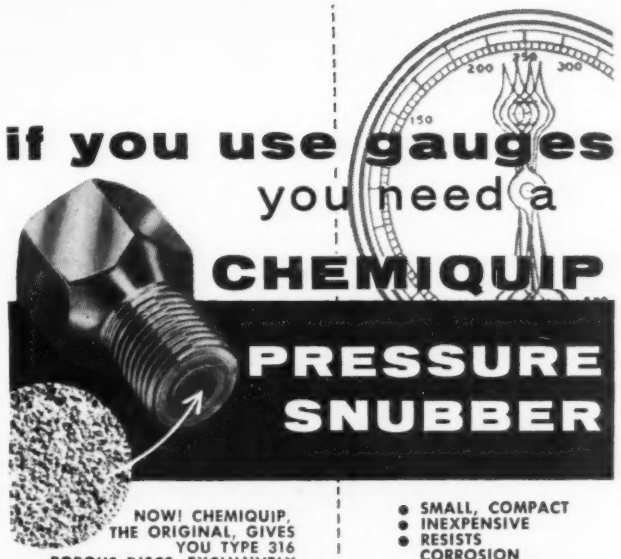
THE RESULTS: "No resonant frequencies"; "no movement of any component"; and "more resistance to fatigue . . . because the force required to dislodge the component under dynamic conditions after the insertion-withdrawal test *increased*"!!!!

ATLAS E-E CORPORATION

47 Prospect Street • Woburn, Massachusetts
3757 Wilshire Boulevard • Los Angeles, California

CIRCLE 47 ON INQUIRY CARD

if you use gauges you need a CHEMIQUIP PRESSURE SNUBBER



NOW! CHEMIQUIP, THE ORIGINAL, GIVES YOU TYPE 316 POROUS DISCS, EXCLUSIVELY

What they do: Chemiquip pressure snubbers give steady average pressure reading—smooth out pressure impulses and fluctuations—eliminate pressure gauge failure due to shock—remove harmful solids from actuating fluids. Available in ⅛", ¼" and ½" NPT.

Popular uses: dampening pulsations and surges; for mercury manometers, metering, and filtering small quantities of liquids or gases.

Write today for illustrated fully-detailed Bulletin E-19.

- SMALL, COMPACT
- INEXPENSIVE
- RESISTS CORROSION
- EASILY CLEANED
- NO MOVING PARTS
- CONFORMS WITH U.S. NAVAL SPEC. MIL-D-2940

AVAILABLE IN STAINLESS STEEL, BRASS, DURAL OR MONEL

CHEMIQUIP CO. 462 W. BROADWAY NEW YORK 12, N. Y. GR 7-3772

CIRCLE 49 ON INQUIRY CARD

Clean, uniform, exact heat to match the size and shape of your production equipment

CHROMALOX Electric Strip Heaters

Quickly and easily bolt or clamp Chromalox Electric Strip Heaters to your platens, dies, kettles, tanks, pipes, ovens, air ducts, for the many advantages obtained only with electric heat.

Lengths 4" to 96" Widths ¾" to 2½"
Cross-section curving or lengthwise bending.
Ring Diameters 2½" to 11"
115, 208, 230, 480 Volts 35 to 5,000 Watts
Sheath Materials: rust resisting iron, high temperature chrome steel, Monel
Choice of convenient terminal placements.

FREE BULLETIN—Call your Chromalox Representative . . . or write today for Bulletin F1566.

Edwin L. Wiegand Company
7900 Thomas Boulevard, Pittsburgh 8, Pa.

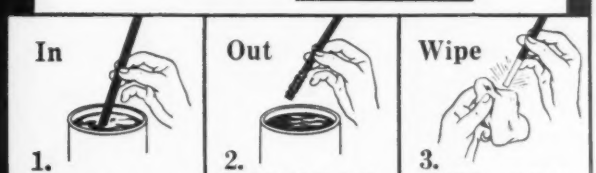
C-2108

CIRCLE 48 ON INQUIRY CARD

NEW! REVOLUTIONARY!

SUPER X-VAR

Removes "Hard-to-Strip" FORMVAR, FORMEX, & ENAMEL insulation In Seconds!



1. DIP WIRE in SUPER X-VAR for 3 seconds.
2. WITHDRAW. Expose to air. Watch coating disintegrate.
3. WIPE CLEAN. Operation completed in seconds!

New Super X-Var quickly removes coatings that X-Var can't remove or removes slowly. Non-corrosive and leaves wire ready for soldering. Now in use by leading manufacturers of electrical products.

Request free sample for test use.

Fidelity Chemical Products Corp.
476 Frelinghuysen Ave., Newark 5, N. J.

International Division
15 Moore St., N.Y.C. • Cable "CHURCHIN" New York

CIRCLE 50 ON INQUIRY CARD

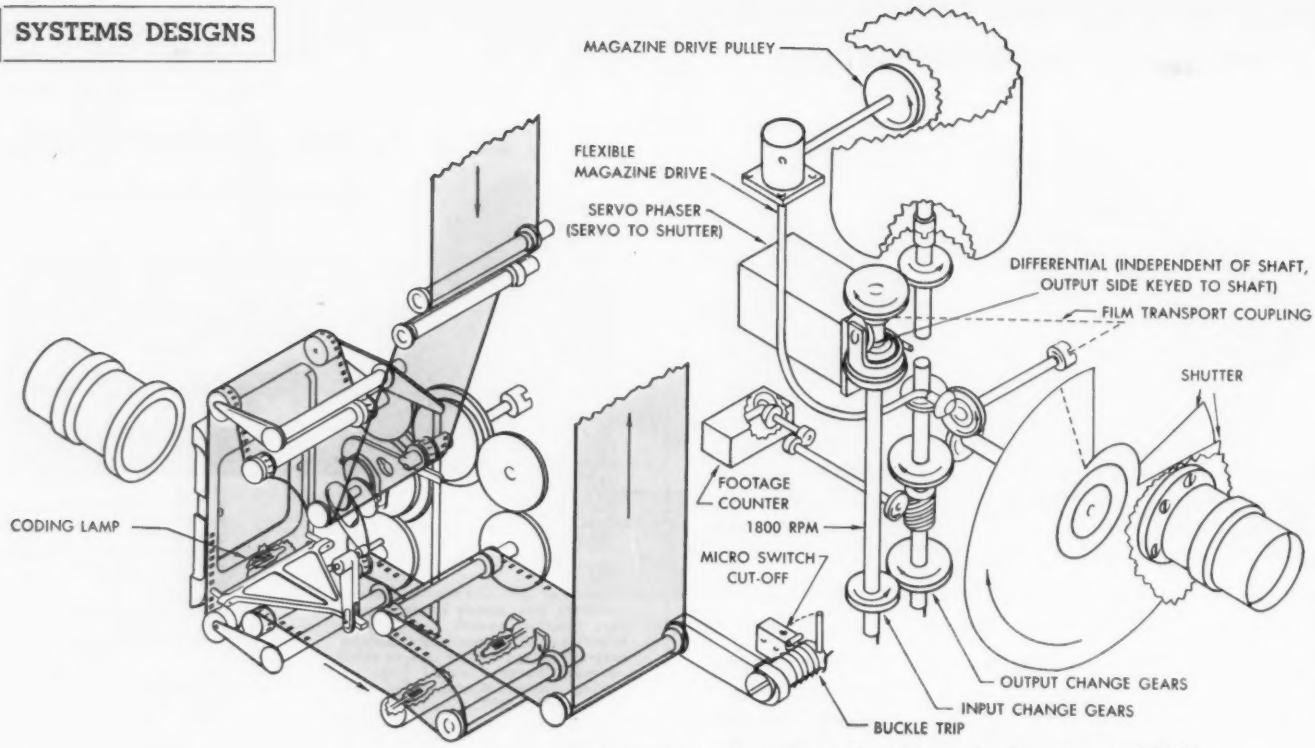


FIG 2—To reduce the vibration inducing forces Flight Research's engineers designed the entirely new type of film transport mechanism above. In this new mechanism a set of reciprocating rollers replaces an intermittent claw mechanism.
Because of the mechanical advantage obtained in the rollers, the roller mechanism needs to move less than ¾ inch to move the film the entire required 2.34 inches. Since the time allowed for this motion remains the same, the acceleration of the mechanism is reduced in direct proportion to the distance reduction or to less than one third that required with a claw type mechanism. The vibration forces are proportionally reduced. In addition to the reduction in the actual value of the vibration forces the short travel required permits the cam mechanism to be designed so that rollers return to the top of their stroke at constant velocity. During this constant velocity period, when there are, of course, no acceleration forces, the shutter is opened and the picture taken. No vibration inducing forces occur during the actual picture taking portion of the cycle.

MISSILE TRACKING

No Bounce in the Camera

An increase to 70 mm motion picture film from the more conventional 16 or 35 mm is a must at many test bases to permit wide-area coverage with the large magnification required to see a fastmoving missile at long range. Problem of providing such a 70 mm camera which operates at speeds almost four times as fast as conventional silent motion picture cameras was solved by Flight Research, Incorporated, of Richmond, Virginia, in the design of their new MULTIDATA® Model V Missile Tracking Cameras.

Charles A. Gregory, Jr., Flight Research's Technical Director, pointed out that the major objective in the design of this camera—in addition to the more usual ones of convenience, ruggedness and reliability—was the reduction to nearly zero of vibration induced by the camera mechanism. Since these cameras may be used on lenses having almost 200 power magnification, any vibration caused by the camera could completely spoil the picture. Remembering how difficult it is to hold a pair of 7-power binoculars still enough to see clearly a distant object may make the magnitude of the problem clearer.

At the design speed of 60 frames per second, the film must be carried through the camera at the rate of 11.7 feet per second or 702 feet per minute. During each second the portion of the film in back of the lens must be stopped 60 times and held perfectly flat, perfectly still and exactly 2.34 inches from the preceding frame.

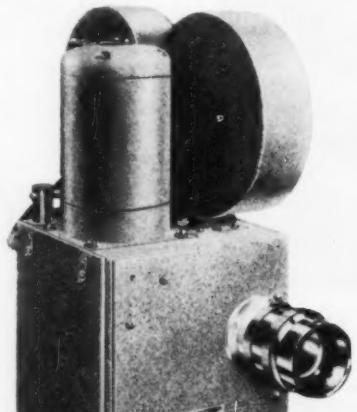


FIG 1—Vibration levels in Flight Research's 70 mm precision data-recording camera, specifically designed for missile tracking, are low enough to permit the camera to operate at high speed even when mounted on the longest focal length telescopes.

FILM TRANSPORT

The normal motion picture camera achieves the film transport function by driving the film at a constant speed with sprockets except at the aperture behind the lens where the film is isolated from the sprockets by a free loop similar to an expansion loop in a pipeline. A cam driven claw engages a sprocket hole in the film at the aperture, pulls the film forward one frame, disengages, and returns to the top of its stroke where it engages a new sprocket hole and repeats the cycle. In

a full-frame 70 mm camera this claw must move 2.34 inches down during the film movement portion of the cycle, stop and move 2.34 inches back to the beginning of the cycle. This start and stop movement requires acceleration which in turn requires that forces proportional to this acceleration be applied to the claw and consequently that there be reaction forces on the camera body. Since these reaction forces are cyclic in nature, inevitably some vibration is induced.

To get some idea of the forces involved, here is the minimum acceleration which can be applied to such a claw and which would occur if an accelerating or decelerating force were applied at all times. In this constantly applied acceleration case, calculated over a quarter cycle for simplicity:

$$a = 2s/t^2$$

where s = distance travelled, or
(2.34/2) inches x (1/12) (ft/inch);
t = time in which ¼ cycle must be completed
or ¼ cycle x (1/60) (sec/cycle)
for the maximum speed design considered here.

Inserting these values for s and t in the above equations the acceleration becomes

$$a = 11{,}232 \text{ ft./sec.}^2 \text{ or } 350 \text{ g's}$$

A minimum cyclic driving force of 350 pounds for each pound of claw mechanism is, therefore, trying to induce vibration in the camera body at all times.

Flight Research's new film transport design that solves this vibration problem is shown in Fig. 2.

SHUTTER PHASING

In almost all missile tests the photographic record is used with other sources of data. Ease of photographic data reduction is increased considerably if pictures can be taken at exactly known times and at equal time intervals.

A servo loop accomplishes this objective by adjustments in the speed of the camera mechanism so that the midpoint of the shutter opening of the camera occurs at the same time as a master time signal. The schematic block diagram of this servo loop and its function is in Fig. 3.

OUTPUT PULSE

The output pulse described in the servo loop of Fig. 3 serves four different purposes:

- to compare to a master time signal to permit accurate shutter phasing,
- to flash lamps in the camera aperture which illuminate reference (fiducial) markers.
- to drive a tachometer which indicates the frame rate at which the camera is operating,
- to provide a reference signal which shutter phasing and the master time signal is sensed by comparing the time of an output pulse generated in the camera exactly at the midpoint of shutter opening to the time of the master time signal. Time discriminator senses the magnitude and direction of this error and feeds an error signal to the servo amplifier which drives the servo-motor in the proper direction. As the differential gears change the phasing of the shutter with respect to the master time signal, the camera-generated output pulse continuously feeds back through the servo loop so that only the proper correction is made without overshoot.

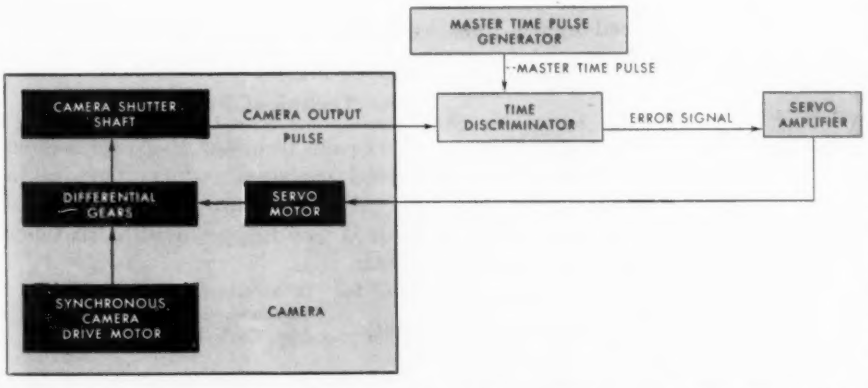
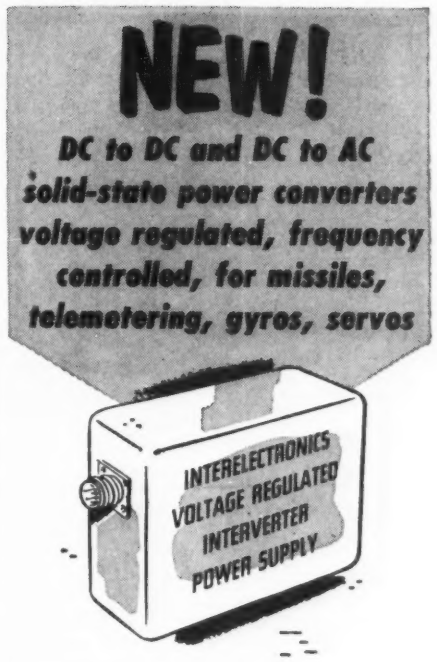
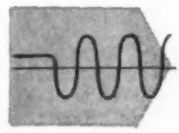
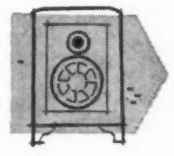
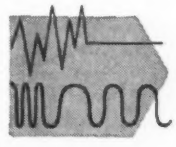


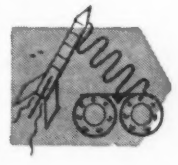
FIG 3—A 3 phase synchronous motor drives the entire camera mechanism and provides the basic speed stability. The problem of fine adjustment to phase the shutter of the camera to the master time signal is overcome by a servo-motor driven differential gear mechanism which can be driven on command to speed up or slow down the main camera mechanism with respect to the drive motor speed. Servo-driven differential can be used either to bring the shutter opening into phase with the master time signal at start-up of the camera or may be run continuously to adjust for small errors in the line frequency driving the main camera drive motor. Error between camera

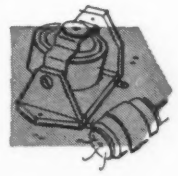












Interelectronics Interverter solid-state thyratron-like elements and magnetic components convert DC to any number of voltage regulated or controlled frequency AC or filtered DC outputs from 1 to 1800 watts. Light weight, compact, 90% or better conversion efficiency.

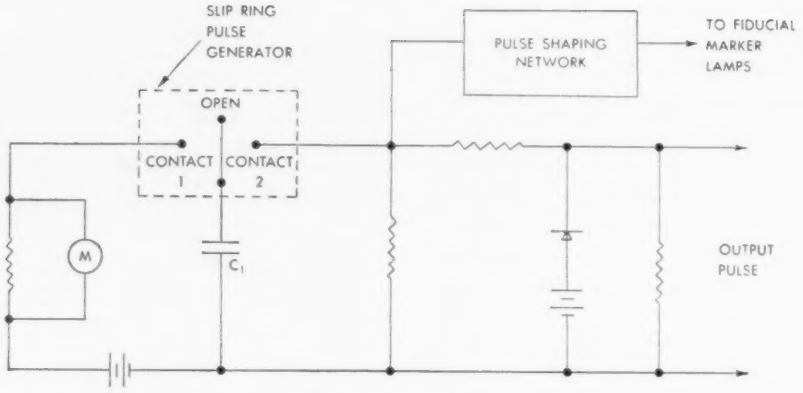
Ultra-reliable in operation, no moving parts, unharmed by shorting output or reversing input polarity. Complies with MIL specs for shock, acceleration, vibration, temperature, RF noise.

Now in use in major missiles, powering telemetering transmitters, radar beacons, electronic equipment. Single and polyphase AC output units now power airborne and marine missile gyros, synchros, servos, magnetic amplifiers.

Interelectronics — first and most experienced in the DC input solid-state power supply field, produces its own solid-state gating elements, all magnetic components, has the most complete facilities and know-how—has designed and delivered more working KVA than any other firm!

For complete engineering data write Interelectronics today, or call LUdlow 4-6200 in N. Y.

INTERELECTRONICS CORPORATION
2432 GR. CONCOURSE, N. Y. 58, N. Y.
CIRCLE 51 ON INQUIRY CARD



SIMPLIFIED OUTPUT PULSE CIRCUIT SCHEMATIC

FIG. 4—The pulse generator is a segmented slip ring designed to form a single-pole-double-throw switch. It spends one third of a cycle on each active contact and one third in the open division. When the switch is on contact 1, the current charging condenser C_1 passes through the tachometer meter. Proper choice of time constants insures that the charge passed through the meter is constant for each switch closure regardless of shutter shaft speed. Average current passing through the meter, therefore, depends solely on the number of switch closures per unit time and consequently on the rotation rate of shutter shaft (camera frame rate). Meter face is calibrated in the standard frame rates of the camera and the time constant of the meter movement itself is long enough to average the current through the meter, providing direct reading of camera speed in frames per second. Pulses required for shutter phasing, fiducial marker illumination and auxiliary timing are initiated by the closure of the slip ring switch to contact 2 and the discharge of condenser, C_1, through a resistive load.

may be fed to auxiliary instruments to record the exact time at which each picture is taken.

Except for the driving of the tachometer, all of these objectives require the pulse to occur exactly at the midpoint of shutter opening—the time at which the picture is considered to have been taken. Since the size of the shutter opening may be varied between 0 and 120 degrees, the pulse generator must adjust automatically to occur at midpoint for all settings of shutter opening.

To provide adjustment of the shutter opening, two separate shutters are mounted on concentric shafts. The pulse generator is a segmented slip ring mounted concentric with the shutter shafts.

This slip ring is held in relation to the shutter shafts only by a pin which is fixed to the slip ring but which rides freely in crossed 45 degree helical slots in the two shutter shafts. When the shafts are rotated with respect to each other to change the effective shutter opening, the slip ring is rotated only half as far and is thus held always at the midpoint of the shutter opening. (See Fig. 4 for details.)

Shutter phasing and auxiliary timing pulses are essentially the same pulse and are passed through a pulse shaping network which produces a pulse with a rise time of approximately 10 microseconds and the pulse is clipped to obtain a flat top of 4 milliseconds duration and 30 volt magnitude. The network is designed to feed into a 1000 ohm load and the pulse is made available for use outside the camera through two separate connectors.

Firing of the fiducial marker lamps requires a special pulse. Fiducial markers can be lighted only during the time the film is stationary since any blurring of the image would seriously hamper their use in making accurate measurements on the film. The film is stationary only during the time the shutter is open. In the most extreme condition—a 15 degree shutter opening at a frame rate of 60 frames per second—the time available for the lighting of the fiducial markers after the pulse is initiated at the midpoint of shutter opening is only

$$\frac{7\frac{1}{2}\text{ degrees}}{360\text{ degrees}} \times \frac{1}{60}\text{sec} = \frac{1}{2880}\text{ sec}$$

or 350 microseconds

To fire the lamps this rapidly the pulse from the slip ring is passed through a pulse shaping network so that the lamps are hit with an initiating pulse of approximately 300 volts.

OTHER DESIGN PROBLEMS

It was found experimentally that AR-9, argon filled lamps, fired much more reliably in this fiducial marker lamp circuit than did any of the many varieties of neon filled lamps which were tried. Neon lamps, were, however, found to be quite satisfactory for operation in a timing code projection system incorporated in the camera to permit the application of a 1000 cycle binary time code on the edge of the film.

Printed circuit boards were used in the pulse forming networks. Mounting the fiducial marker lamps on a printed circuit board at the camera aperture permitted very simple replacement of the lamps by replacement of the entire board. The lamp assembly can then be checked in the maintenance shop and any necessary replacements can be made under easier working conditions than at the usual camera installation.

Flight Research's designers feel that the incorporation in the camera of the unique film transport and the shutter phasing system as well as a number of other features specifically aimed at improving and simplifying the obtaining of accurate photographic data has produced a camera which will solve many of the problems of the present-day photographic engineer.

WORTH FILING

New Technical Publication

Eight-page technical magazine slanted toward engineers and management in the airborne instrument and control fields is now being published six times a year.

Issued by: G. M. Giannini & Co., Inc., Pasadena, California

For your copy: Circle 145 on Inquiry Card

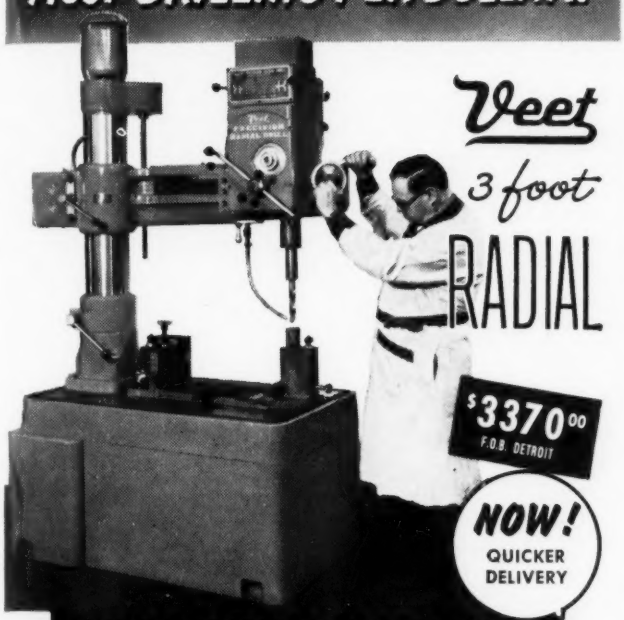
Comparative Heat Exchanger Costs

Twenty-page "Design and Cost" booklet on heat exchangers presents a rapid analysis of the comparable costs between a plain condenser tube and a Trufin Type S/T shell and tube exchanger over the range of the more common applications. Booklet contains applications and design calculations.

Issued by: Wolverine Tube Division, Calumet & Hecla, Inc., Detroit, Michigan

For your copy: Circle 144 on Inquiry Card

MOST DRILLING PER DOLLAR!



Veet 3 foot RADIAL

$3370.00 F.O.B. DETROIT

NOW! QUICKER DELIVERY

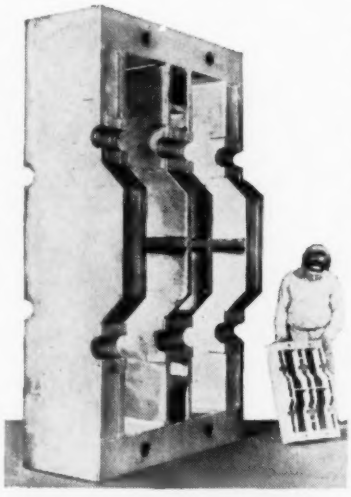
RADIAL MOBILITY AT THE PRICE OF A FIXED SPINDLE DRILL!

Send for brochure describing VEET'S 16 Points of superiority

MFGD. BY Veet INDUSTRIES EAST DETROIT, MICH.
TEL. PRescott 6-3000

CIRCLE 52 ON INQUIRY CARD

WELDMENTS MAKE SENSE



Press Cap Weldment
(showing small scale pattern)

Weldments eliminate pattern costs and permit alteration without destroying the entire assembly. (Ideal for machinery use . . . change over).

•

Write for folder about our services and equipment for the production of Flat-Die Forgings — Weldments— Composite Die Sections and Plate Burning.

COMPOSITE FORGINGS, INC.
2300 W. JEFFERSON, DETROIT 16, MICH.
Phone TAshmoo 5-3226

CIRCLE 53 ON INQUIRY CARD

HOW TO SATISFY A CUSTOMER

Package your products in Lermer Plastic durable, handsome containers. They are shatterproof, 75% lighter than glass, available clear or opaque in many colors, can be printed or decorated and are available with metal or plastic closures. Write for complete catalog information and samples. If possible, send along products for particular suggestions.

LERMER PLASTICS, INC. Garwood, N. J.
REPRESENTATIVES IN THESE CITIES: Rochester, Memphis, Miami, Cincinnati, Columbus, Cleveland, Chicago, Detroit, Minneapolis, San Francisco, Los Angeles, Toronto, Philadelphia.

PIONEERS AND SPECIALISTS IN PLASTIC CONTAINERS

CIRCLE 54 ON INQUIRY CARD

SPEED TYING OPERATIONS with Hanscom WIRE-TIES

NEW! Wire-Tie Dispenser!

Save! Stock only spools of Wire-Ties! "Pay-Off", manual "single-motion "dispenser, automatically measures and cuts off any preset length 2" to 22" with single pull! Only $59.50 complete. Write for folder.

Top view of Wire-Tie is Shown. Bottom is flat.

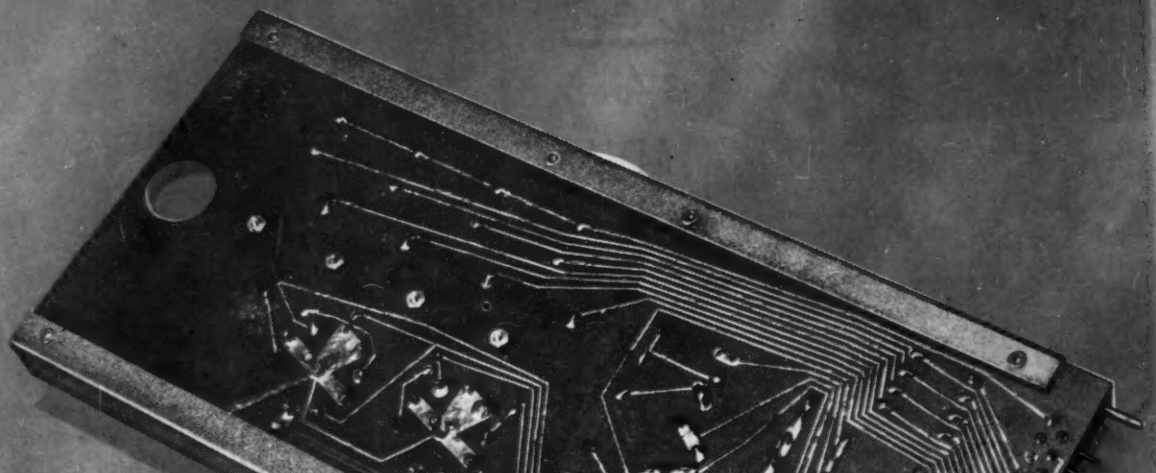
NO KNOTS TO TIE!

Cut your tying time in half! Wire-Ties are the fast, sure way to bundle wires, cords, coils, etc. Nothing to tie. Just wrap 'em around and twist. For temporary or semi-permanent holding. Available in cut lengths 1" to 20" and on spools — plain colors or printed. Prices from 55c per thousand. WRITE FOR SAMPLES and TRY 'EM YOURSELF. H. F. Hanscom & Co., Inc. 12 Virginia Ave., Prov. 5, R. I., U. S. A.

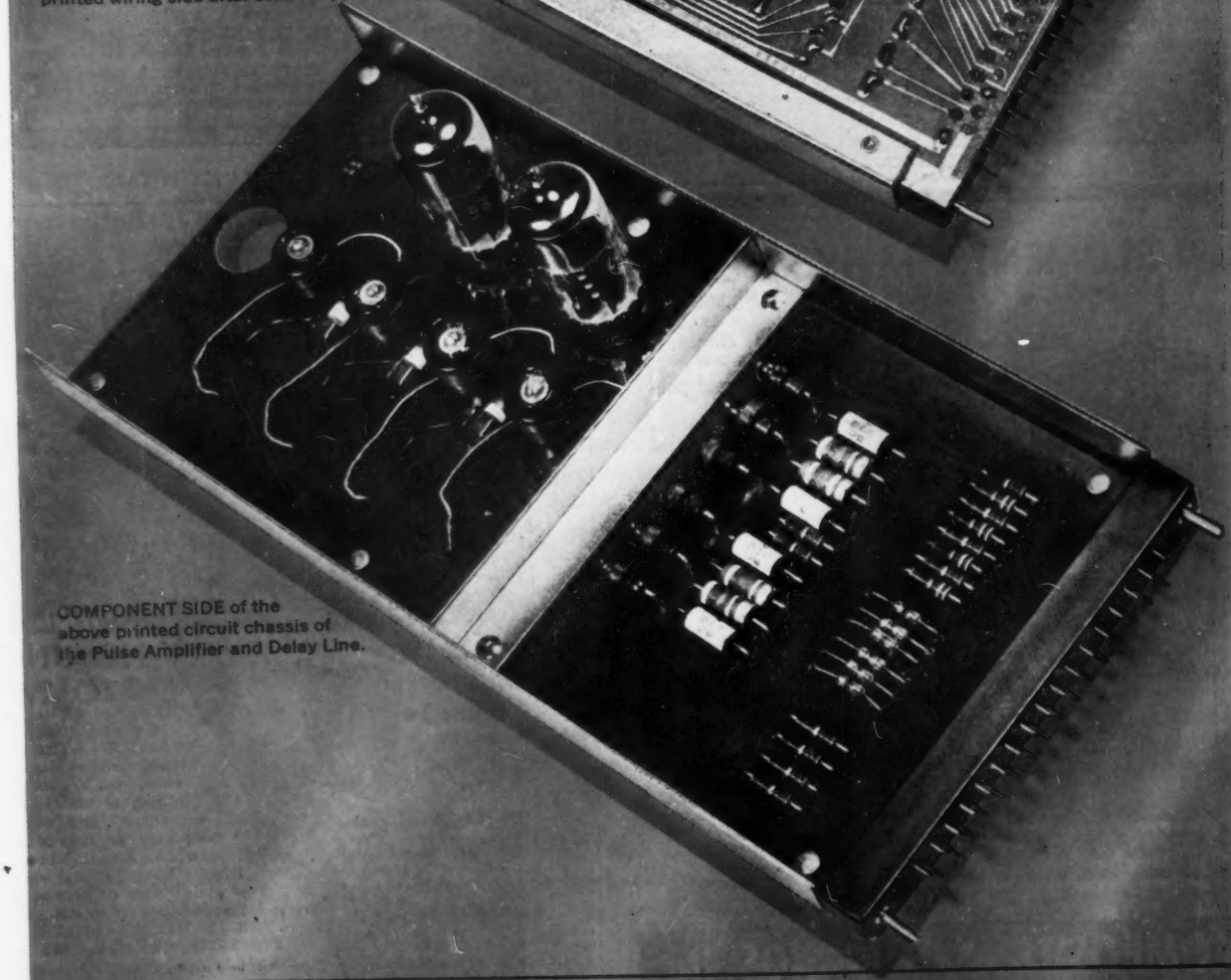
Hanscom® WIRE TIES

CIRCLE 55 ON INQUIRY CARD

"HIGHLY DEPENDABLE,"



PLUG-IN PRINTED CIRCUIT CHASSIS used in Univac File Computer showing printed wiring side after solder dip.



COMPONENT SIDE of the above printed circuit chassis of the Pulse Amplifier and Delay Line.

ays Remington Rand Univac*

of the

REVERE ROLLED COPPER

used in its Printed Circuits

A leader in the manufacture of digital computing systems, Remington Rand Univac utilizes the latest manufacturing techniques because computing systems require printed circuit boards completely free of defects.

In examining copper-clad laminated boards made with Revere rolled copper Remington Rand Univac said, "We found even the finest lines were freer from pits, pinholes and other imperfections. In addition, there were no detectable lead inclusions. Also, the rolled copper thickness is uniform. We get what we specify."

Designed and developed by Remington Rand Univac, digital computers use hundreds of printed circuits. Each one must operate according to specifications at all times. There can be no sacrifice of conductivity. Because of more uniform etching qualities Revere Rolled Copper is capable of producing better edge definition, allowing closer spacing of lines. A uniform solder coat under normal or automatic soldering operations is possible because the copper is free from surface defects. Fluxes wet readily because of this clean surface. These factors combine to make Revere Rolled Copper the ideal medium for these printed circuit boards.

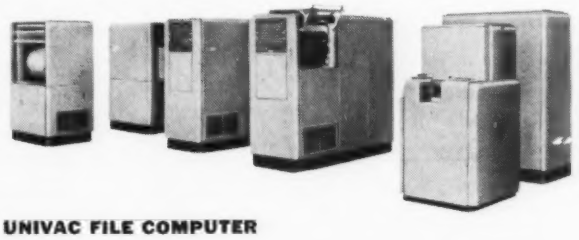
And they are the very reasons why you should insist that Revere Rolled Copper be specified by you when ordering blanks from your laminator.

It is available in unlimited quantities in standard coils of 350 lbs. in widths up to 38" and in .0014, .0028, and .0042 gauges, weighing approximately 1 oz., 2 oz. and 3 oz. per square foot; or heavier if required. Many users have found that because of its unique characteristics 1 oz. Revere Rolled Copper can be used instead of the 2 oz. required when other kinds of copper are used, thus effecting still greater savings in material cost. Revere Rolled Copper exceeds requirements of standard specifications and meets ASTM B5 specifications for purity with 99.9% minimum.

Consult your laminator regarding the use of Revere Rolled Copper for your printed circuits, or contact the Revere Representative nearest you through the yellow pages of your local telephone directory.

Revere does no laminating of printed circuit boards, making only rolled copper. Revere Rolled Copper can also be furnished rolled down to .0006 for coil winding applications.

*Reg. U. S. Pat. Office



UNIVAC FILE COMPUTER

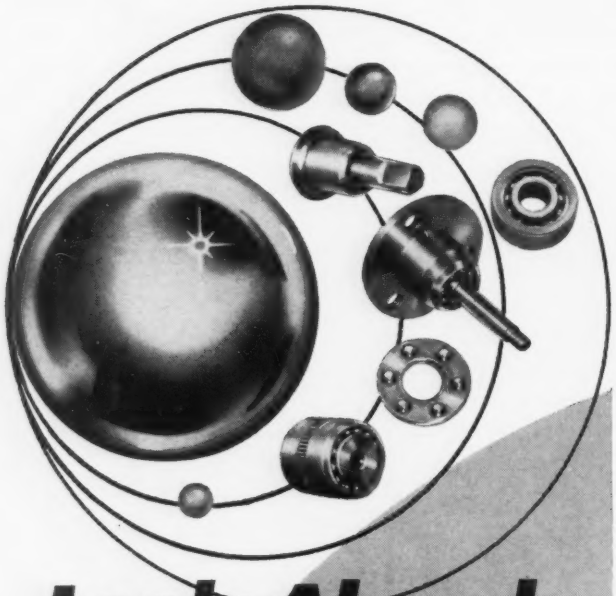
REVERE COPPER AND BRASS INCORPORATED

Founded by Paul Revere in 1801

230 Park Avenue, New York 17, N. Y.

Mills: Rome, N. Y, Baltimore, Md.; Chicago, Clinton and Joliet, Ill.; Detroit, Mich.; Los Angeles and Riverside, Calif.; New Bedford, Mass.; Brooklyn, N. Y.; Newport, Ark.; Ft. Calhoun, Neb. Sales Offices in Principal Cities, Distributors Everywhere.

COPPER ★ BRASS 18 01 ★ REVERE ★ ALUMINUM



Look Ahead

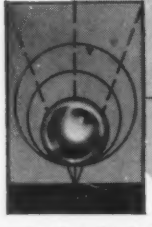
with Hartford

on your precision ball and special bearing requirements

Hartford's Look Ahead Policy anticipates increasing engineering requirements. The balls are manufactured to increasingly close tolerances and finer surface finishes from a wide range of materials able to withstand increasingly higher temperatures, more severe corrosive conditions and unusual wear problems.

Many difficult bearing problems are solved by Hartford engineers. For example, through unitization of parts, miniaturization and reduction in tolerance build-up is achieved with VERSA-TWIN, a double-row ball bearing in which parts of the end product form the inner and outer races. This bearing can be custom designed to your specific requirement.

Hartford also makes a complete line of thrust retainers, angular contact and wheel bearings. Technical literature is available on all lines.



Hartford BALLS • BEARINGS

Hartford Steel Ball Co., Inc., 19 Jefferson Ave., West Hartford, Conn.

CIRCLE 57 ON INQUIRY CARD

STAFF COLUMNIST

Israel Katz

Israel Katz is manager of Liason and Consulting Engineering at General Electric's Advanced Electronic Center in Ithaca, N. Y.

THE HEART OF THE MATTER

The Combined Environment: A Challenge to Design Resourcefulness

Research and development efforts are increasingly challenged by the inability of electromechanical devices to cope with environmental extremes and by severe degradations in the performance of complex function when exposed to severe conditions. Wherever the problems have been perplexing in the past, the engineer has somehow pressed on. Today, he must remain confident that impediments will again yield to resourceful attack despite the sobering realization that important barriers have been approached and that he may be forced to operate within bounds set by apparently unextendable limits and inalterable physical laws.

Designers of electromechanical components and systems must hereafter meet the threat posed by hazardous physical factors and effects acting in combination. While anyone of these factors or effects, alone, might seriously damage a device or degrade its performance, their combined action may well rule out the possibilities of using many advanced components, existing or anticipated. The heart of the matter is that a sophisticated definition and appraisal of the challenge is essential.

MILITARY FLIGHT VEHICLES

Concern about the combined environment stems from the postulation of military flight vehicles capable of hitherto unattainable speeds. Very high levels of propulsive power must be developed to achieve those speeds. Effects associated with related energy conversions and transfers, supersonic airflow around the vehicles and the dynamic properties of the aircraft, will introduce something new and different in the line of physical environments. Other troublesome effects are bound to arise from strength limitations imposed on vehicle structures, by a need for weight conservation, and local disturbances resulting from hostile measures that may be directed against the vehicles in order to destroy them or defensive actions intended to increase weapon system survival probabilities.

The purpose at hand is to discuss briefly, and within limits set by military security, the deleterious extremes of temperature, pressure, radioactivity, acoustical noise, vibration, shock and certain chemical changes, as functions of both natural and induced circumstances, that may prevail during high speed flight of military vehicles. The objective is to focus attention on critical problem areas and stimulate interest in the development of electromechanical components and systems able to meet the pressing need.

ANTICIPATED ENVIRONMENTAL EXTREMES

Hazardous environmental extremes will occur simultaneously and prevail during the most critical intervals of the vehicles' missions. Values may vary considerably during

can VIBRATION MEASUREMENTS Help You ?

MARINE ENGINE MEASUREMENTS — PHOTO COURTESY GENERAL METALS CORPORATION

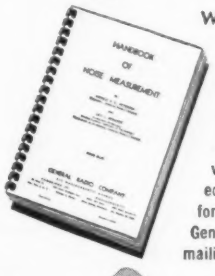
Vibrations cause discomfort and fatigue and, in extreme cases, can bring about actual failure of structural materials. Conversely, they are helpful too, making possible vibrating systems such as the electro-dynamic shaker for testing components and equipment. Whether wanted or unwanted, vibrations must be measured to obtain a thorough understanding of their characteristics and potentialities. Such measurements are accomplished accurately and with ease and rapidity by the G-R Vibration Meter and Vibration Analyzer.

The Vibration Meter measures motion directly in terms of its displacement, velocity, and acceleration. The piezoelectric type of pickup used permits a frequency range of 2 to 1000 cps (120 to 60,000 rpm), covering the spectrum in which vibrations are most often encountered. The instrument is mounted in a portable case, operates from an internal battery, and is simple and easy to use.

The Vibration Analyzer is a continuous spectrum instrument, invaluable for determining the contribution made by specific frequencies to the over-all disturbance. "Broad" and "Sharp" bandwidths are provided for either scanning or for detailed measurements over the range from 2.5 to 750 cps (150 to 45,000 rpm). The complete analysis made possible by this instrument provides the clues to the sources of the various components and gives information necessary for the suppression of the vibration.

. . . They Helped Here!

- The Vibration Meter is widely used for evaluating the effectiveness of shock and vibration mounts and cushioning for high-speed automatic machinery.
- A tire manufacturer uses this measuring equipment to determine accurately the amount of vibration absorbed by auto tires.
- Resonant vibrations in large engine foundations have been analyzed with success. The frequency spectrum of the disturbance gives a most helpful indication of the offending gear, pinion, or other part.
- Field measurements on marine and stationary engine installations are extremely valuable safety measures; they help predict troubles brought about by excessive torsional vibrations.
- Ball bearing manufacturers rely on vibration measurements to test the finished product as it comes off the production lines.
- Noise levels of several popular fans and air circulators have been reduced to acceptable levels through vibration study.
- Measurements on newly completed vehicles, ships, and large fixed structures are necessary to check design calculations.
- Excessive building vibrations produced by engine and heavy-machinery operations on upper floors have been reduced as a direct result of investigations conducted with the G-R Vibration Meter and Analyzer.
- Rotational vibrations of electrical machines and generators can be determined with the aid of two vibration pickups and a simple summing circuit which feeds the Vibration Meter.



Write for Complete Specifications

Many of the applications briefly described above are discussed in detail in the G-R Handbook of Noise and Vibration Measurement. This comprehensive publication of well over 160 pages thoroughly covers the subjects of noise and vibration measurements; it describes standard measuring equipment and techniques, and gives definitions and procedures for interpreting results. The booklet is available from the General Radio Company at a cost of $1.00 to cover printing and mailing charges only.

GENERAL RADIO Company

275 Massachusetts Avenue, Cambridge 39, Mass., U.S.A.

Broad Avenue at Linden, Ridgefield, N. J. **NEW YORK AREA** 920 S. Michigan Ave. **CHICAGO 5**

1150 York Road, Abington, Pa. **PHILADELPHIA**

8055 13th St., Silver Spring, Md. **WASHINGTON, D. C.** 1000 N. Seward St. **LOS ANGELES 38**

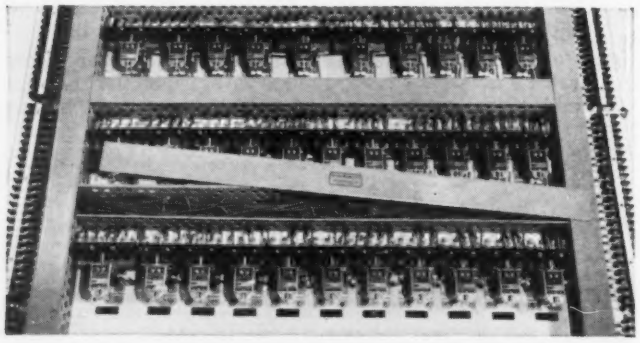
FOR MORE INFORMATION CIRCLE 58 ON INQUIRY CARD

Using New-Type Taylor Wiring Ducts

So easy to use—you just lay your wires in the duct, put them through holes to terminals, then snap on the cover—FAST and EASY. No wasting time with cover screws, hinges or mounting brackets.

And you get many advantages through this new, better way to wire electric and electronic control panels. Speeds up production; eliminates costly time-consuming lacing, flat wiring or bundling. *A cinch to maintain!*

Taylor Wiring Ducts are non-combustible, warp-resistant, acid-resistant, light in weight yet durable and rigid. You can cut them with a saw, tinsnips—even a jackknife!



A WIDER RANGE OF STANDARD SIZES THAN ANY OTHER DUCT

Round-Hole Type—from ⅜″ up to 4″ W x 3″ H
Slotted Type—from 1″ x 1″ up to 4″ W x 3″ H

Write for sample, literature, and prices
TAYLOR ELECTRIC, INC.
15048 Dale Ave., Detroit 23, Mich.
KEnwood 5-2500

D-2

CIRCLE 59 ON INQUIRY CARD

those periods due to certain transient factors, but it is a foregone conclusion that the peak values will be most troublesome and persist over sufficient time to constitute a major threat to equipment performance. Expected rates of change of these environmental factors cannot be disclosed here, but extreme values may be indicated as follows:

►The maximum temperature that will occur in any unconditioned space within the vehicles may be equal to the stagnation temperature of the relative freestream air. Conditioned space temperatures will be variable, with difficulty, between the atmospheric temperature at the flight altitude and the stagnation temperature of the freestream air. Equipment penetrating the skin of a vehicle, or somehow exposed to boundary layer air, may risk being heated to the stagnation temperature of the freestream air.

►Unless the space were to be inhabited, the prevailing pressure probably will be equal to the atmospheric pressure at the flight altitude. For all practical purposes, most electromechanical equipment must be designed to operate within the pressure range from 0 to 15 psia. The pressure of inhabited compartments will rarely fall below 10 psia.

►Nuclear radiation flux levels, and spatial distributions thereof, relating to postulated nuclear propelled vehicles are known, but classified. Despite this knowledge, estimates of radiation that equipment may absorb during a mission vary enormously. On the whole, nuclear flux levels will be relatively low, in fact, so low, it seems necessary to indicate that most nuclear radiation tests of equipment, upon which a great deal of information has already accumulated, are being conducted at unrealistically high-dosage levels.

►Radiation flux levels in chemically propelled aircraft carrying nuclear weapons will be negligible except during periods of nearby weapon burst. If the vehicle escapes destruction by violent aerodynamic disturbances attending a nearby burst, the nuclear irradiation of equipment may be negligible, but the flux still might be sufficiently intense to constitute a lethal dose to unshielded personnel.

►Intense acoustical noise will be a serious source of trouble and result from the high rates of energy exchange in the engines and supersonic airflow over the external surfaces of the vehicles. Noise levels at combat power are expected to range between 120 to 190 db, based upon the A.S.A. Standard Reference of 10-16 watts per square centimeter. Noise levels will be highest at engine discharge nozzles. An overall noise gradient exceeding 60 db may exist between the forward internal compartments of the airframe and the engines' exhaust gas exits. Acoustical frequencies probably will range between 30 and 10,000 cycles per second.

►Aerodynamic disturbances in the slipstream, flutter of airframe structures, buffeting of the aircraft, engine vibration, and thermal draft in the path of the vehicles will lead to troublesome mechanical vibrations. Frequencies ranging from 0 to 2000 cps should be expected. Rapid accelerations between 5 g and 10 g probably will attend these vibrations. Because the vehicles may be stressed to survive shock loads due to singular accelerations in excess of 50 g, electromechanical devices to be installed therein must be designed to resist the associated strains. The shock loads may endure for periods of 10 milliseconds and produce structural deformations in equipment supports up to 0.10 inch.

►The roll, pitch, and yaw capabilities of supersonic aircraft

OILITE

IN AN AUTOMATIC WASHER HELPS BUILD CUSTOMER SATISFACTION -YET COSTS NO MORE

OILITE bronze agitator shaft bearing
OILITE bronze upper center post bearing
OILITE bronze rubber-mounted lower center post bearing
OILITE bronze thrust washers (2)
OILITE bronze pulley bearing
OILITE bronze thrust bearing
OILITE bronze water pump bearing

Photos courtesy Whirlpool-Seeger Corporation St. Joseph, Michigan

Another cost-saving application of Amplex Powder Metallurgy

Quality is a *must* for trouble free operation, continued customer satisfaction. And quality depends upon the excellence of every part, every component. For many years Whirlpool-Seeger has used OILITE center post bearings, agitator shaft bearings, water pump bearings and pulley bearings in their automatic washers. Whirlpool-Seeger uses these and other OILITE parts for very good reasons.

First of all, the manufacturer knows OILITE heavy-duty bronze bearings will meet specifications. Chrysler-Amplex precision production assures him OILITE bearings capable of carrying their loads safely, surely and quietly.

Then too, Chrysler-Amplex plant and facilities—largest and most complete of any in the metal powder fabrication industry—promises on-time deliveries in any quantity.

Moreover, in using OILITE bearings the manufacturer selects a product his customers know and respect for superior engineering.

Finally, this manufacturer, like a great many others, finds OILITE bearings—despite all their advantages—cost no more.

Chrysler-Amplex representatives and dealers are located in principal cities in United States and Canada. Let the nearby representative help you. Find him in the yellow section of your telephone directory under—"Bearings—OILITE."

Representatives and dealers located in principal cities in United States and Canada.

A CHRYSLER OILITE PRODUCT

Only Chrysler Makes **OILITE**

AMPLEX DIVISION

CHRYSLER CORPORATION • DETROIT 31, MICHIGAN

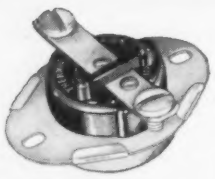
It's New! It's Free!

S-56; Standard OILITE Bronze Bearing Stock List. All standard sizes—over 1000 sleeve, flange and thrust bearings, cored, bar and plate stock—are listed in this handy, easy-to-use booklet. Write for your copy today. Address: Dept. 9M, Chrysler-Amplex Division, P.O. Box 2718, Detroit 31, Michigan.

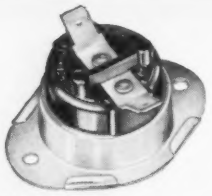
Bearings • Finished Machine Parts • Permanent Metal Filters • Friction Units

Ferrous and Non-Ferrous Metals

FOR MORE INFORMATION CIRCLE 60 ON INQUIRY CARD



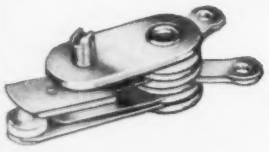
TYPE EA
best suited for controlling temperatures in air streams.



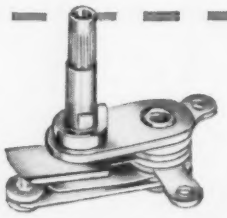
TYPE EC
designed for surface mounting.

- high ratings with minimum size
- preset, snap action, non-adjustable . . . for operating temperatures up to 350° F.
- available with blade or screw terminals.

resistive load — 6000 Watts at 240 Volts A.C., 3000 Watts at 120 Volts A.C.



TYPE A— non-adjustable



TYPE A— adjustable

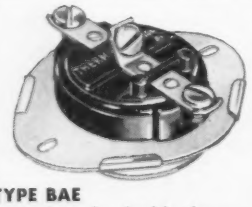
- slow make or break contacts
- for operating temperatures up to 550° F.

resistive load — 1650 Watts at 120 Volts A.C.

Therm-O-Disc
thermostats

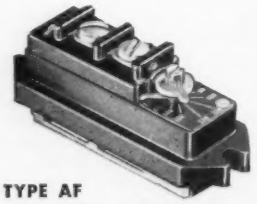
TYPE HL
- single pole, single throw or double pole, single throw.
- manual or automatic reset.
- preset, snap action, non-adjustable . . . for operating temperatures up to 300° F.

resistive load— 40 Amperes at 115 Volts A.C., 25 Amperes at 230 Volts A.C.



TYPE BAE
- single pole, double throw.
- preset, snap action, non-adjustable . . . for operating temperatures up to 350° F.

resistive load — (across contacts 1 and 3) 6000 Watts at 240 Volts A.C., (across contacts 1 and 2) 125 Volt Amperes at 120/240 Volts A.C.



TYPE AF
- fan motor control
- snap action, adjustable . . . for operating temperatures up to 300° F.

fan motor load — ½ hp. at 120/240 Volts A.C.

detailed information upon request — minimum production order quantity accepted — 25

THERM-O-DISC, INCORPORATED mansfield, ohio

FOR MORE INFORMATION CIRCLE 61 ON INQUIRY CARD

will be modest in comparison with those of subsonic types. A rule of thumb that applies here is that as their speeds rise, the dynamic responses of aircraft to controls decrease. Thus, if equipment slew rates can match those of subsonic vehicles, the slewing capabilities of equipment will suffice in the supersonic types. However, since the roll, pitch, and yaw capabilities of supersonic aircraft are typically low, serious problems in automatic guidance of aircraft are introduced because as the dynamic responses of aircraft decrease, it becomes increasingly difficult to effect stable guidance. The reason for this trouble is that the noise level in guidance equipment remains practically constant. Even ball-park numbers for safe roll, pitch, and yaw of supersonic aircraft are classified. Reliable transfer functions pertaining to high-speed supersonic vehicles will not be available in the foreseeable future. Linear accelerations of supersonic aircraft will be extraordinary, much greater than those of any existing aircraft; even speculation of the values is classified.

►Structural deformation of supersonic aircraft also may be severe in the presence of thermal transients in the atmosphere, buffeting, and inertial effects relating to the flying qualities of the vehicles. Electromechanical equipment attached to the airframes will share in much of this deformation. As a result, the angular accuracy of detection equipment and instrumentation, located on structures remote from the vehicles' centers of mass, may suffer unless special precautions are taken to cope with effects of this flexing.

►The pressure, temperature, and humidity of atmospheric air swept by the vehicles will vary considerably as a function of the flight and weather conditions occurring during the missions. Even during flight at intended constant altitude and airspeed, ambient conditions may vary considerably as a result of thermal transients and the relatively large masses of complete weapon systems. Severe fluctuations in engine power output must be expected due to variations in the mass flow of air passing through the engines. These variations will result from changes of atmospheric density in the path of the vehicles. Under certain circumstances, the power fluctuations may be 25 percent of the power required from the engines at the desired flight conditions. The resultant transients may lead to no end of difficulty with the performance of subsystem equipment.

►One of the factors that could increase a supersonic aircraft's vulnerability to destruction and simultaneously degrade the performance of its electromechanical subsystem equipment is the heated wake that may trail for many miles behind the vehicle. Although this trail might be strikingly visible to remote infrared and radar detectors, it may be opaque to the aircraft's own surveillance equipment. Thus, while a supersonic aircraft could readily be observed at the head of its exhaust trail, it may be unable to detect threats obscured by its own wake. The environmental factors that may affect the detectability of an aircraft and the transparence of its wake to its own surveillance equipment are: the thermal structure of the wake; size and length of the wake; chemical composition of wake gases; energy content of the wake; ambient air conditions; boundary layer air temperatures; emissivity of the aircraft skin; thermal radiation from hot spots; and other electromagnetic radiation.

Next issue's column will cover data requirements and recommend design approaches to these problems.

Picture distribution amplifier unit as well as synchronizing generator and power supply units are mounted on Grant Industrial Slides. Units are normally retracted but roll out for servicing.

Grant Slides... Smooth, Fast and Efficient!

DuMont's problem was space

Compactness was the prime requirement for the DuMont Telecruiser — a mobile unit which had to duplicate actual studio operating conditions in every respect.

It was absolutely necessary to confine the servicing operations of various units to a limited area. Consultation with Grant representatives resulted in the selection of the proper (Electronic Equipment) Slides for the DuMont Telecruiser.

Do you have a servicing and maintenance problem?

Grant Research and Development facilities are at your service. Let us assist you in the choice and application of Grant Slides to your equipment. Engineering liaison is available from the planning stage through the production processes.

GRANT INDUSTRIAL SLIDES

a product of the engineering design department of
Grant Pulley and Hardware Company
73 High Street, West Nyack, New York

FOR MORE INFORMATION CIRCLE 62 ON INQUIRY CARD

Use WELDED STEEL for Greater Strength with Less Weight!

Gas Turbine Components are also produced in welded steel. The turbine cylinder housing for a Westinghouse Industrial Gas Turbine, shown above, and the parts and assemblies illustrated at the left, will give you a comprehensive picture of Mahon capabilities and facilities . . . assets which enable the Mahon Company to produce virtually any heavy part or assembly in welded steel at lower cost. This is particularly true in short run production programs where the manifold advantages and economies of weldments are most fully realized. If you require parts or assemblies for processing machinery, machine tools, or any other type of heavy mechanical equipment, you can call on Mahon with complete confidence. You will find in the Mahon organization a unique source for welded steel in any form . . . a source with long experience and complete facilities for design engineering, fabricating, machining and assembling . . . a source where design skill and advanced fabricating techniques are supplemented by craftsmanship which assures you a finer appearing product embodying every advantage of Steel-Weld Fabrication. See Sweet's Product Design File for information, or have a Mahon sales engineer call at your convenience.

THE R. C. MAHON COMPANY • Detroit 34, Michigan

Sales-Engineering Offices in Detroit, New York and Chicago

Engineers and Fabricators of Steel in Any Form for Any Purpose

MAHON

FOR MORE INFORMATION CIRCLE 63 ON INQUIRY CARD

LET ELECTRO BRAINSTORM YOUR PRODUCTION PUZZLES—DEVELOP AN ECONOMICAL SOLUTION TO YOUR SUB-CONTRACTED ELECTRICAL OR ELECTROMECHANICAL ASSEMBLIES. TAKE THIS SLIP RING, FOR INSTANCE: 2000 SEPARATE PARTS PRODUCTIONEERED, FABRICATED, ASSEMBLED, TESTED—PLUS STEADILY DECREASING COSTS OVER A FOUR-YEAR CONTRACT. A NEW SUBCONTRACTING PHILOSOPHY YOU'LL WANT TO KNOW MORE ABOUT.

GOOD CONNECTION FOR SPECIAL COMPONENTS

NON-FERROUS CASTING
DIE-CASTING
PLASTIC MOLDING
PRECISION MACHINING
STAMPING
WIRING
SUB-ASSEMBLY
TESTING
COMPLETE PRODUCTS

AIRCRAFT
AUTOMOTIVE
ELECTRICAL
MARINE
NUCLEAR
ORDNANCE

ELECTRO

ELECTRO-MECHANICAL PRODUCTS CO. • 32702 FORD ROAD • GARDEN CITY, MICH.

FOR MORE INFORMATION CIRCLE 64 ON INQUIRY CARD

NEW TECHNIQUES

PRINTED WIRING DESIGN

New Photographic Technique

Designing for printed wiring is very different from designing for conventional wiring. Mechanical convenience and symmetry, the primary considerations in conventional designs, are secondary in printed circuits. Positioning components to provide the simplest wiring patterns is the major criterion.

Rigid formulas for layout of printed circuits are impractical because of the many variables involved. Designers generally use cut-and-try techniques. Nevertheless, procedures for guiding designers to obtain good designs in a minimum number of trials are practical. Engineers at Westinghouse Electric Corporation have developed such procedures together with new photographic drafting techniques which they have been using successfully throughout their divisions.

These and other procedures and techniques will be demonstrated this Fall by Westinghouse engineers in seminars on functional drafting arranged by the Industrial Education Institute of Boston. The schedule of seminars arranged by the IEI and a discussion of some subjects to be covered are given in another section of this issue.

Here are some of the procedures for designing printed wiring and for drafting circuit diagrams photographically, abstracted from the seminar lecture notes of Mr. R. F. Barrell of Westinghouse. As Mr. Barrell says, since the thought patterns of individuals differ, these procedures need not be followed rigidly, the steps can be modified to fit the individual.

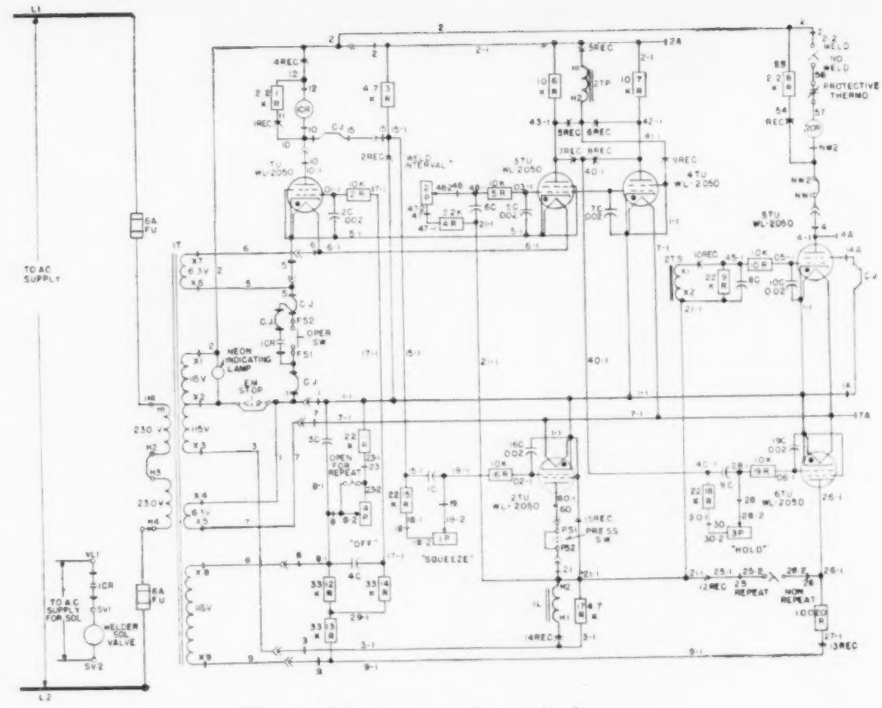


Fig. 1—Illustrative schematic diagram.

ANALYZING THE WIRING DIAGRAM

Inspect the schematic diagram of the circuit to be printed to find those groups of components that appear to be associated with one another.

Using the schematic in Fig. 1 as a guide, make a freehand point-to-point wiring diagram as illustrated in Fig. 2. At this stage, disregard the filament leads and the size or shape of the finished circuit. Starting at any point in the schematic, arrange the wiring so that there is a minimum number of crossed leads. The rough point-to-point wiring diagram will go through many modifications and may need to be completely redrawn several times. Freehand all drafts, of course. The point-to-point wiring diagram in Fig. 2 has been reduced to the minimum number of crossed leads.

In analyzing the wiring diagram certain principles can be applied.

- Since the wiring is on the rear of the panel and the components are mounted on the front, often the components may be used as devices for crossing circuits. Figure 3 shows how a pig-tail resistor can be located so that the lead crosses on the side opposite the wiring.
- Transformers are excellent means

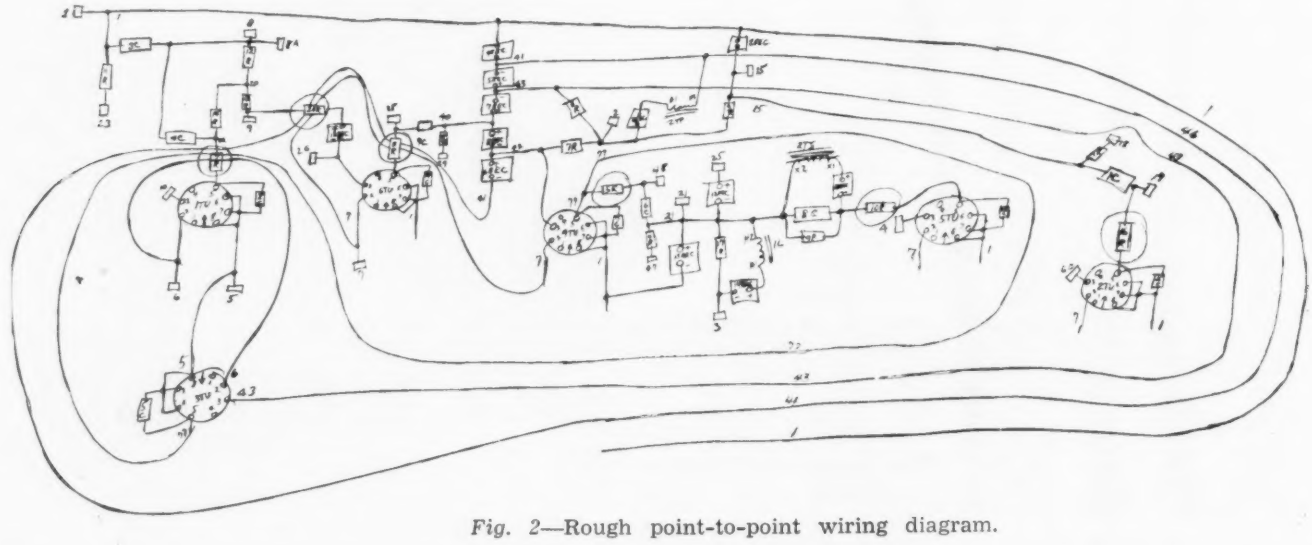


Fig. 2—Rough point-to-point wiring diagram.

for crossing leads.

- Because of the fixed and confining span between selenium rectifier terminals, use of these components for crossing leads should be kept to a minimum.
- In spite of the best attempts at limiting crossed circuits, instances where crosses cannot be spanned by components will occur. In these instances use circuit jumpers. In some cases you can obtain simpler and more compact designs using jumpers. Use jumpers rather than go to extremes to eliminate them.

POSITIONING THE COMPONENTS

Notice in Fig. 2 that tube 5 is all by itself with only the grid lead interconnected with the rest of the circuit. This observation suggests that tube 5 can probably be located any place in the pattern.

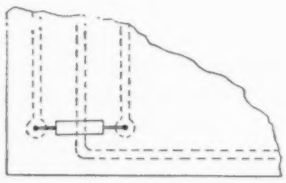


Fig. 3—Pig-tail components, when properly arranged, can be used to cross circuits.

Notice also that the group of components consisting of 2, 3, 5, 6, 7, 8, and 9 REC and 3, 6, and 7R are closely related to tubes 2, 3, 4, 6, which suggest that these tubes be arranged to surround the group of components; that tube 4 is closely related to the components in tube 5 circuit; and that tubes 1 and 6 are related through resistor 7R. Using such facts draw a diagram positioning the tubes according to close relationship as illustrated in Fig. 4.

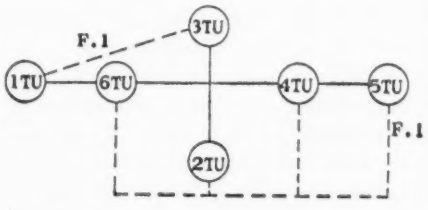


Fig. 4—Relative tube position diagram.

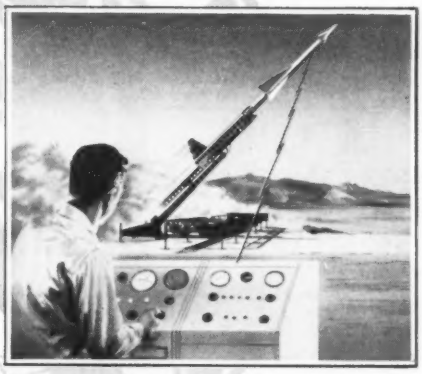
You can now consider how the filament leads should run.

In the tube diagram connect the tubes having a common filament supply as illustrated by the dotted lines in Fig. 4. When the filament lines are add-

BULOVA

FAMED FOR PRECISION SINCE 1875

NEW AM-100



"MULTI-PURPOSE" OVEN

Now Bulova pioneers an entirely *new*, ultra-simplified means of temperature compensation... the "multi-purpose" AM-100 oven.

The AM-100 is designed to yield exacting temperature control of more than just crystals. *Now* entire circuits, components and/or complete sub-assemblies can be housed in one, low cost unit... the highly stable AM-100.

By eliminating costlier, less dependable, heavier and more complex temperature compensating factors, hundreds of design hours can be saved... circuits can be simplified and more dependable, and have a far wider operating range.

THE AM-100 FEATURES: Rugged lightweight construction (less than 7½ oz.); Long life expectancy due to triple insulation on heater winding; High stability ± .1°C.; Standard octal plug-in (stud mounting available); The unit draws 20 watts on initial warm-up, with average dissipation of less than 5 watts after warm-up; Meets vibration tests per MIL-E-5272; Overall 3" diameter x 5" high – cylindrical cavity 1¾" diameter x 2¾" high.

A complete line of precision Bulova ovens are available in quantity, with custom designed units available on request.

BULOVA
watch company

Electronics Division
Woodside 77, N.Y.

Write Dept. A-765
Full Information
and Prices on Ovens

FOR MORE INFORMATION CIRCLE 65 ON INQUIRY CARD

Photograph shows coil-winding operation with Dennison Crepe Paper Tape at Ford Motor Company, Accessory Division, Ypsilanti, Michigan.

Dennison Crepe Paper Tape helps cut insulating costs for the Ford Motor Company

*. . . it can do the same for you!**

Use Dennison stretch-to-shape Tape for better insulation with snugger fit and fewer grounds — at a much lower cost. Available in a wide variety of stretches and widths, including popular 3/8″ size.

What's more – Dennison Crepe Paper Tape offers you these other money-saving advantages:

1. You get at least a 40% material saving over cotton to insulate field coils of fractional horsepower motors or low-voltage generators.

2. You may be able to eliminate varnishing and baking because this tape is made from high-density kraft with a dielectric rating of 1250-1500 volts. If you *must* varnish and bake, you'll gain an even higher dielectric rating.

3. You get fewer grounds from voids. Dennison Crepe Paper Tape is creped to a variety of stretches. It is calendered to reduce overall caliper and assure smooth automatic feeding. It gives a closer, tighter fit than less conformable materials. A tensile strength of 54 lbs. on a 1″ strip solves the problem of winding under tension on standard equipment.

***Try it at our expense!** Simply mail the coupon and we'll send you enough Dennison Crepe Tape for comprehensive tests.

Dennison

Dennison Manufacturing Company
310 Howard Street, Framingham, Mass.

Gentlemen: Please send free sample roll of Dennison Industrial Crepe Paper Tape.

55XHC dielectric tape — Regular — 50% stretch
☐ 3/8″ width ☐ 1/2″ width

55XHCW dielectric tape—Wax Oil Impregnated—50% stretch
☐ 3/8″ width ☐ 1/2″ width

Name .....

Address .....

.....

FOR MORE INFORMATION CIRCLE 66 ON INQUIRY CARD

ed, the tube configuration may have to be modified slightly to obtain the optimum circuit pattern.

LAYING OUT THE CIRCUIT PATTERN

After the tube relationships (Fig. 4) have been established, you are ready to lay out the circuit pattern. Select any scale and cut a sheet of velum or film having the approximate proportions of length to width preferred for mechanical reasons. Redraw the point-to point wiring diagram locating the tubes in the chosen relative positions. Experience has shown that tubes should be located on the outside of the tubes next to the edge of the panel avoiding filament lead interference.

Location of tube sockets at the edge is recommended because the strain on the circuit as tubes are removed and replaced will be minimized there, since printed circuits are generally supported by structural members at the edges.

Having established the component layout, redraw the point-to-point circuit diagram to obtain a rough circuit pattern as illustrated in Fig. 5.

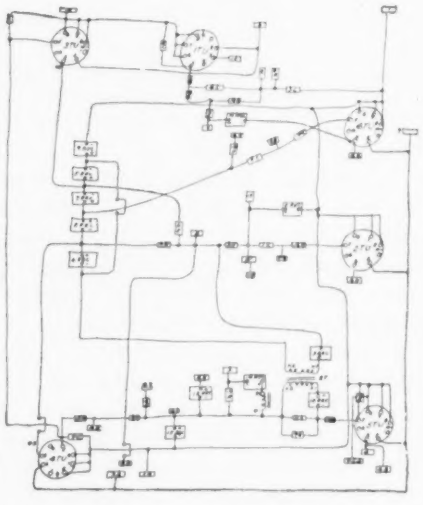


Fig. 5—Point-to-point wiring diagram with components relatively positioned.

With this rough pattern you can now make a mechanical layout of the components to scale. Westinghouse uses photographic drafting techniques for this purpose. The principal instruments of this technique are symbolettes—transparent film copies of tracings showing the outline dimensions and drilling dimensions of the components. A mechanical layout made by this technique is called a symbolette layout.

MAKING THE SYMBOLETTE LAYOUT

Place a sheet of matte-finish vinyl film over the rough circuit pattern (Fig. 5).

Position symbolettes of the components according to the arrangement of the pattern and stick them down by double coated cellulose adhesive tape. Pig-tail components should not be positioned diagonally with respect to the axes of

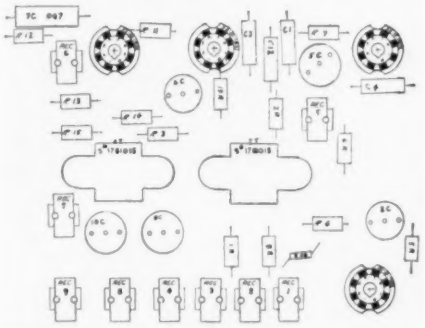


Fig. 6—Symbolette layout.

the panel (see symbolette layout Fig. 6). The layout is now ready for preparation of the printed circuit original.

PREPARING THE PRINTED CIRCUIT ORIGINAL

Label each component on the symbolette layout according to the symbol on the schematic diagram.

Place a sheet film over the symbolette layout and draw the circuit in with pencil as illustrated in Fig. 7.

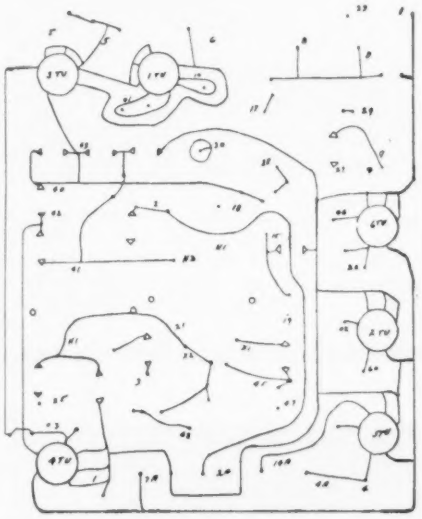


Fig. 7—Printed circuit pattern.

Mark each lead with the schematic lead number so that the circuit can be checked against the schematic diagram. The circuit pattern is now ready for making the black and white original by procedures that are fairly standard.

PHOTOGRAPHIC DRAFTING

Symbolettes, useful in printed wiring design, can also be used in making circuit drawings, drilling templates and panel drawings as shown on page 78.

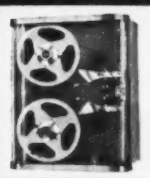
FOR DATA PROCESSING COMPONENTS AND SYSTEMS

SPECIFY POTTER

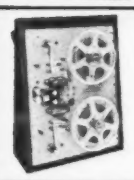
Potter instruments and systems are unexcelled in reliability, accuracy and flexibility. The equipment shown is typical of many more available as individual components or in integrated systems to meet specific requirements.

Write for brochure describing these and other Potter units, including special products. For detailed technical specifications on any of the Potter Products listed above, contact your Potter Representative or the factory.

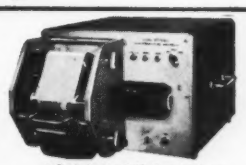
DATA-HANDLING EQUIPMENT



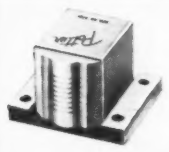
Digital Magnetic Tape Handlers



Perforated Tape Readers



"Quick Look" Recorders



Record-Playback Head Assemblies

Record-Playback Amplifiers

PRESET INTERVAL GENERATORS

Preset Interval and Delay Generators

HIGH SPEED ACCESS REGISTERS

Ten-Bit Parallel Output (Serial Input) Using Magnistors

Ten-Bit Serial Output (Parallel Input) Using Magnistors

Six-Bit Digital Comparator Using Magnistors

POTTER INSTRUMENT COMPANY, INC.
115 Cutter Mill Road Great Neck, L. I., N. Y.

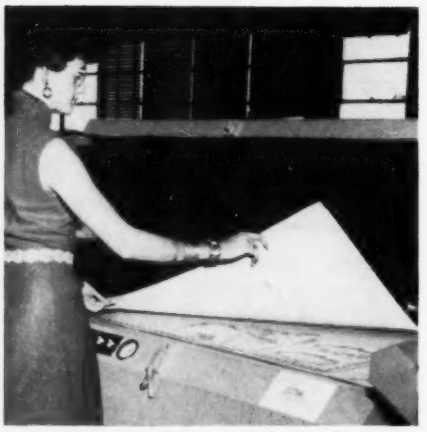
FOR MORE INFORMATION CIRCLE 67 ON INQUIRY CARD

NEW TECHNIQUES

MAKING THE DRILLING TEMPLATE USING SYMBOLETTES.

1. PULLING SYMBOLETTES. Any number of film symbolettes for each component or repetitive part can be printed from a tracing in an ordinary diazo machine. Symbolettes can then be filed in the drafting department.

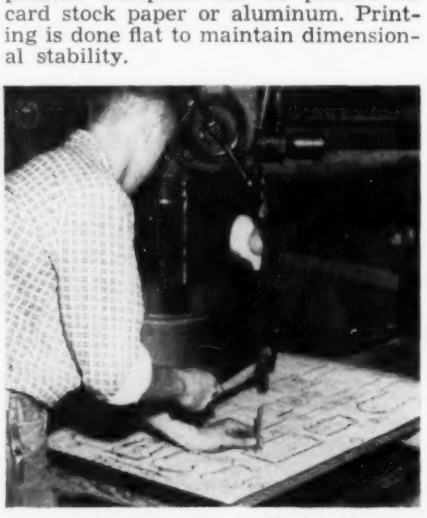
2. TEMPLATE IS ARRANGED. "Layout Sheet" is placed over a precision aluminum grid. Film symbolettes are then arranged and held with cellophane tape.



3. PRINTING THE TEMPLATE. Template layout is placed on a flat box vacuum printer. Template can be printed on card stock paper or aluminum. Printing is done flat to maintain dimensional stability.

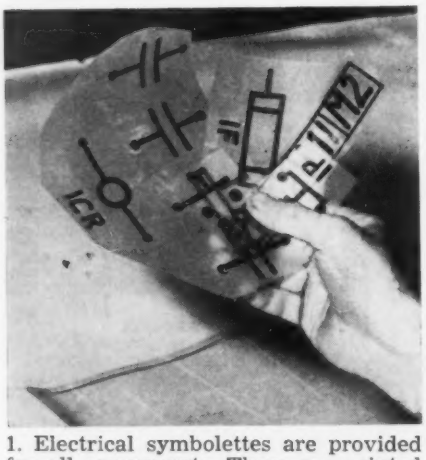
4. DEVELOPING THE TEMPLATE. Template is developed at the printing location. All materials used have daylight emulsions.

5. FINAL TOUCHES. Special information can be recorded on the template using india ink.



6. FINISHED TEMPLATE. Finished template can now be forwarded to the machining section where it will be used to locate component mounting holes. Templates eliminate costly layout operations and human errors.

MAKING THE PANEL DRAWING USING SYMBOLETTES.



1. Electrical symbolettes are provided for all components. These are printed on diazo film similar to film for templates and photo assembly drawings.

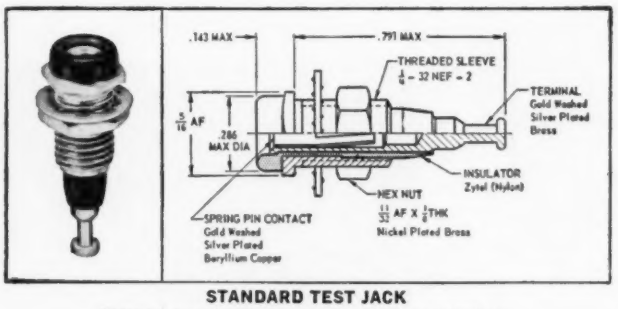
2. Symbolettes are arranged by diagram draftsman and forwarded to photo department where tracing is made.

3. Stripped-up original is printed back on to a diazo drawing form. Wiring legend is then completed.

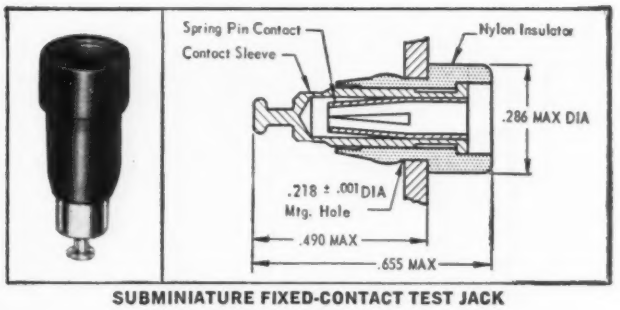
new...from Raytheon TEST JACKS

Now the most complete quality line in the industry . . .

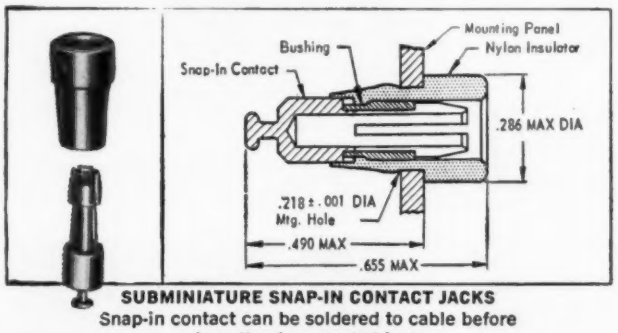
All your test jack needs from one reliable source—Raytheon. These brand new components offer a unique combination of highly desired features. Nine colors. Nylon insulators. Beryllium-copper contacts with silver-plated gold-washed solder terminals. Designed for extreme salt spray, humidity, temperature conditions. For standard .080" prods. These jacks conform to military specs. and are **competitively priced.**



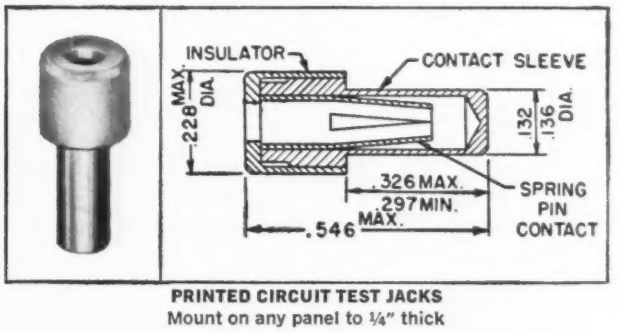
STANDARD TEST JACK
Rugged construction, superior design. Ideal for extreme shock and vibration conditions



SUBMINIATURE FIXED-CONTACT TEST JACK
Fast, easy, press-fit assembly



SUBMINIATURE SNAP-IN CONTACT JACKS
Snap-in contact can be soldered to cable before insertion in mounted jack

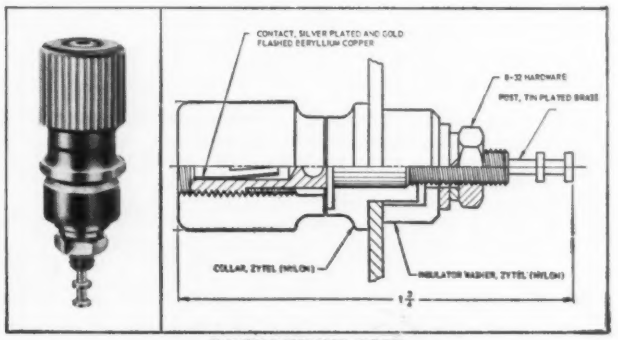


PRINTED CIRCUIT TEST JACKS
Mount on any panel to ¼" thick

For complete information, please write Dept. 6120

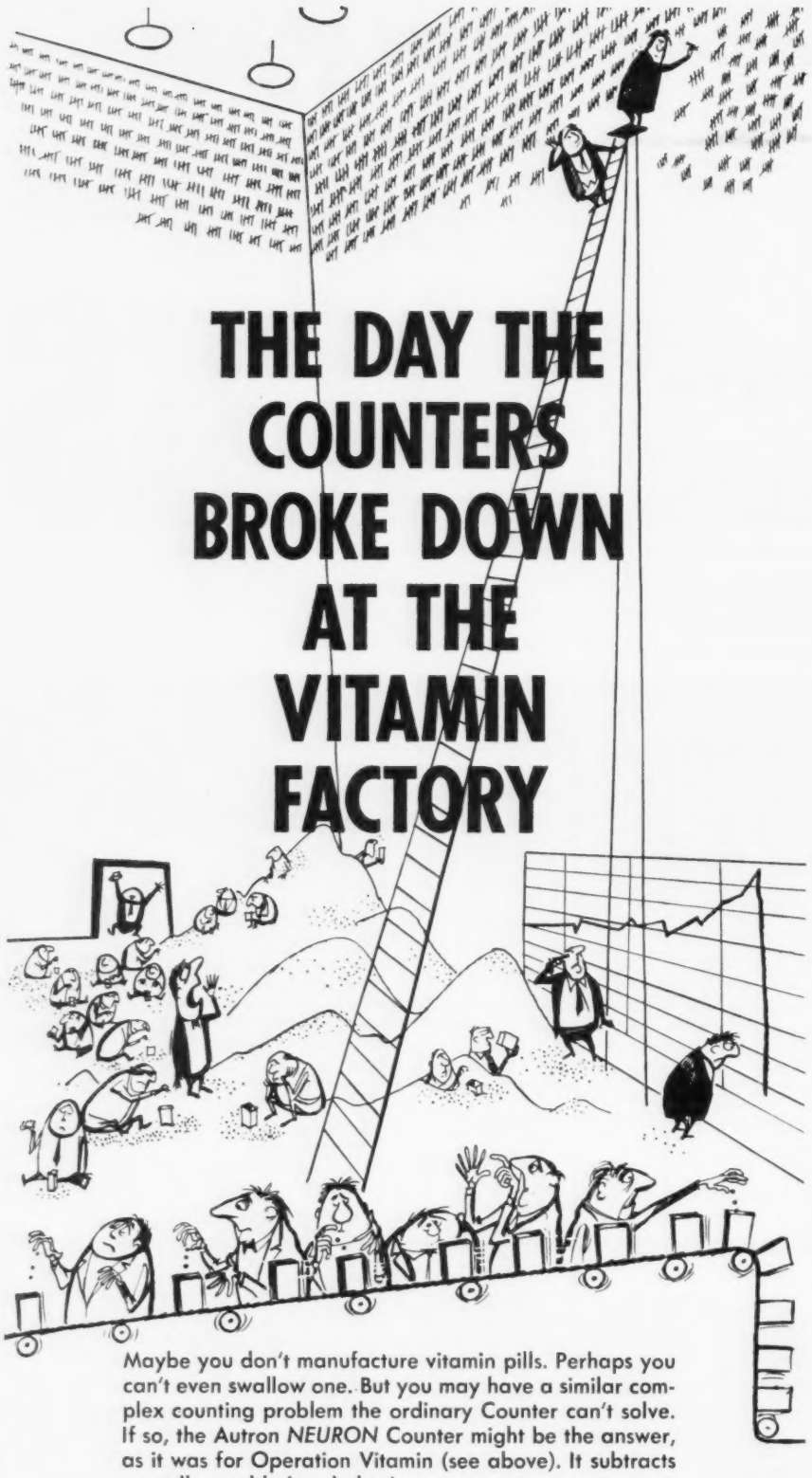
Excellence RAYTHEON *In Electronics*

RAYTHEON MANUFACTURING COMPANY
Commercial Equipment Division
Waltham 54, Mass.


CONTACT, SILVER PLATED AND GOLD FLASHED BERYLLIUM COPPER
8-32 HARDWARE
POST, TIN PLATED BRASS
COLLAR, ZYTEL (NYLON)
INSULATOR WASHER, ZYTEL (NYLON)

5-WAY BINDING POST
Compact, high strength. Incorporates jack for banana plug or standard .080" prod. Available in black or red

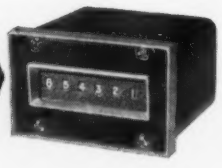
FOR MORE INFORMATION CIRCLE 68 ON INQUIRY CARD



THE DAY THE COUNTERS BROKE DOWN AT THE VITAMIN FACTORY

Maybe you don't manufacture vitamin pills. Perhaps you can't even swallow one. But you may have a similar complex counting problem the ordinary Counter can't solve. If so, the Autron *NEURON* Counter might be the answer, as it was for Operation Vitamin (see above). It subtracts as well as adds (see below).

The "NEURON" counters epitomize the most advanced electro-magnetic counter technology, featuring high speed (to 60 PPS), long life (in excess of 300 million cycles), pulse reset, switch readout, bi-directional drive (add and subtract), and small size. These precision units may well be the answer to your tabulation problems.



Autron
ENGINEERING, INC.

For further information, write to Irwin Aldrich, 1254 WEST SIXTH STREET
LOS ANGELES 17, CALIF.
Offices in major cities

FOR MORE INFORMATION CIRCLE 69 ON INQUIRY CARD

NEW TECHNIQUES

ULTRASONIC DRILLING

Now Produces Tube Spacers

An ultrasonic ceramic-drilling technique developed by C-Mar Corporation, Manasquan, N.J., makes possible, for the first time, volume production of close-tolerance ceramic parts with intricate configurations. C-Mar has applied the technique to the manufacture of alundum tube spacer disks which triple tube life and minimize noise.

The electromechanical transducer used in the drilling process converts alternating current into mechanical force to vibrate an impact tool at 25,000 cycles per second. Particles of abrasive, introduced as a slurry between work and tool face, are driven with tremendous impact to reproduce an exact counterpart of the tool face in the workpiece. As a result, intricate orifices, multiple arrangements of holes and slots, and other complex configura-

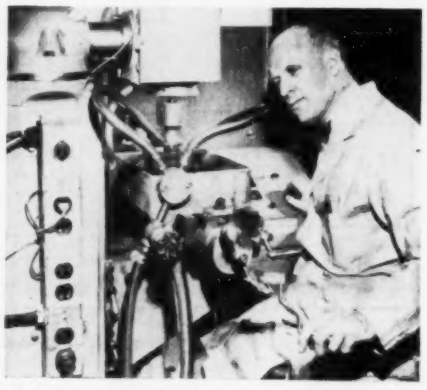


Fig. 1—Skilled operator machines intricate configurations into alundum tube spacer disks. While operator's right hand tunes ultrasonic generator, his left hand controls tool feed into the work piece.

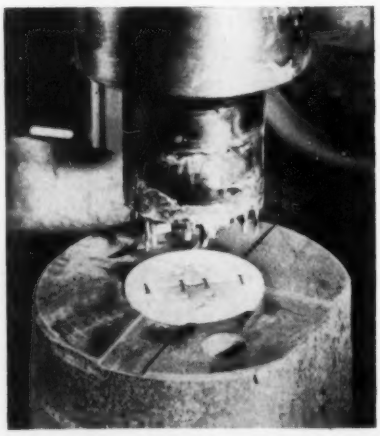


Fig. 2—All slots and holes are cut simultaneously as the tool drives abrasive into ceramic spacer at ultrasonic rate of 25 kc.

tions are cut into the workpiece in a single operation. Because the work is not chipped, spun, stressed or distorted, parts can be shaped to close tolerances with high reproducibility.

The alundum (aluminum oxide) tube spacers, developed for a manufacturer of ruggedized tubes, replace conventional mica spacers with a melting point of 1757 F. Alundum's melting point of 3750 F allows higher internal tube temperatures, more complete degassing, and a quieter, longer life. The idea of using aluminum oxide spacers was suggested by the durability of alundum splash disks in tubes.

Impact tool design was one of the most difficult problems in producing these tube spacers. A single tool is good for about 25 pieces, after which the worn tool bits must be replaced. To make these tools with consistent, reproducible accuracy, C-Mar built a layup template of tool steel (Fig. 4). The template holds the 24 separate bits precisely in place while they are silver brazed to the cone of the ultrasonic grinder.

Circle 136 on Reader Inquiry Card.

Fig. 3—Life of this ruggedized tube is tripled by replacing conventional mica spacers with ceramic spacer disks.

Fig. 4—Layup template used in producing drilling tool for alundum spacer. The mild tool steel shanks all butt against a large recess in the end of the monel cone of the ultrasonic grinder.

BISHOP...

Producer of World Famous

BI-SEAL

(The Electrical Tape With A Memory)

Offers 5 Electrical Tapes for Moisture Sealing, High-Voltage Splicing, Jacketing, Insulation Build-Up, and All-Purpose Taping.

FOR PERMANENT MOISTURE SEALING

Bi-Seal Self-Bonding (polyethylene based) Electrical Tapes. Water absorption as low as .0065%. Operating temperatures range from –55°C. to 85°C. Power factors are .0006 and .0021 for 1000 cycles.

FOR HIGH-VOLTAGE CABLE SPLICING

No. 30 High Voltage Splicing Tape. Developed especially for splicing cables insulated with ozone-resistant compounds and operating at 2000 volts or more. Superior ozone and corona resistance.

FOR PERMANENT CABLE JACKETING

Bi-Prene (neoprene) Jacketing Tape. For splicing neoprene-sheathed cables. Protects against ozone, heat, moisture, sunlight, oil, grease, hydrocarbons and chemicals, particularly acids. Flame resistant.

FOR RAPID INSULATION BUILD-UP

No. 125 Electrical Filler Tape. ⅛" thick insulating compound in tape form. Easy to mold to any shape. Fuses to a solid, flexible mass. For cable splice build-up, covering sharp cornered connectors, padding bus bars, cable end sealing.

FOR GENERAL INSULATING AND JACKETING PURPOSES

Vinyl Electrical Tapes. Thin, tough pressure-sensitive tapes with great adhesive strength. Offer complete electrical and mechanical protection for most general taping problems. Highly elastic. High dielectric strength.

Write for complete catalog information.

BISHOP

BISHOP MANUFACTURING CORPORATION

20 Canfield Rd., Cedar Grove, New Jersey

FOR MORE INFORMATION CIRCLE 70 ON INQUIRY CARD

Square *RE*-USABLE Metal *Pad-Kaging* Containers

ELIMINATE majority of handling and storage problems

REDUCE shipping weights and cubic footage

These RE-USABLE Metal Pad-Kaging Containers were developed by PETERS-DALTON for the U. S. Armed Forces. They have been approved and are in use for shipping and storing innumerable items.

P-D Containers eliminate the storing of many cumbersome and highly inflammable materials—they also eliminate the excess labor usually required in packaging such items as delicate radar instruments. Older methods caused finished packages to be heavy and bulky. They were susceptible to breakage and penetration to moisture and fungus. They were wasteful because of their excessive use of man-hours and materials, culminated by the eventual scrapping of the expensive packaging. Also, when reshipping was required, old fashioned containers after having once been opened, were seldom satisfactory for adequate repackaging of the materials — endangering them to damage while in transit. These inadequacies and limitations have been virtually eliminated through P-D RE-USABLE Metal Shipping Containers,

★ ★ ★

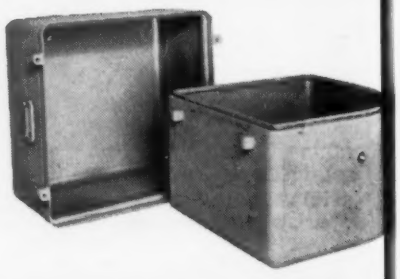
Features include: Lightness: Completed packs weigh far less than older style types. Compactness: The P-D RE-USABLE Metal Containers frequently save more than 50% of cubic footage. Economy: Material and man-hour outlays for packaging are reduced 25%.

Special Features: Containers are equipped with air fill valves to eliminate dangers of fungus or moisture and dial type humidity indicators. Drop handles furnished for containers weighing less than 200 lbs.—heavier containers have been designed for fork truck lifting. Extremely simple to close, only ordinary bolts (4 on the smallest container to 14 on the largest) are required; the simplest of hand tools perform the closing or opening operations. Optional: Pressure relief valves to equalize inside to outside pressures.

☆ ☆ ★

These RE-USABLE Metal Containers were manufactured by PETERS-DALTON for items ranging from aircraft engines, electronic parts, to large A-N containers in all types and sizes for shipping purposes. Complete engineering and manufacturing facilities are at your disposal for design, testing and fabricating. We'll be glad to tell you more—just write, wire or phone.

Materials formerly used in pac aging one light military electron item.



Only two parts to handle.

P-D Re-Usable Container ready be closed and sealed. Note

STEEL SHIPPING CONTAINER DIVISION

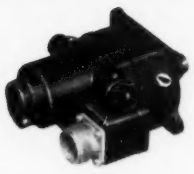
Peters-Dalton INC.

A SUBSIDIARY OF DETROIT HARVESTER CO.

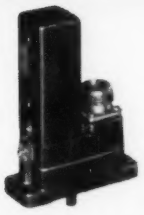
- Hydro-Whirl Paint Spray Booths
- Industrial Washing Equipment
- Drying and Baking Ovens
- Hydro-Whirl Dust Collecting Systems

QUALITY ACTUATORS FOR QUALITY PRODUCTS

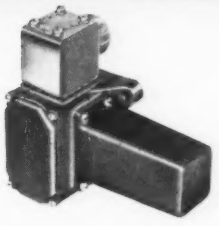
THE ACTUATORS



1002750 90° Geneva-Loc Actuator

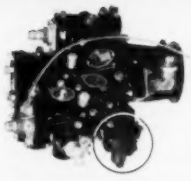


554260 Miniature 2-Position Rotary Actuator



1010535 Multi-Position Rotary Actuator

TYPICAL INSTALLATIONS



J-57 Fuel Control Installation

Turbine-Driven Hydraulic Power Unit for B-52

Turbo-Propellor Pitch Control

THE COMPANY BEHIND THE ACTUATORS

Bendix-Pacific in North Hollywood comprises five fully equipped manufacturing plants.

The Electro-Mechanical manufacturing department at Bendix-Pacific where actuators are produced.

A nationwide service organization stands behind all Bendix-Pacific actuators and other products.

Today's advanced engineering demands top quality from each component more than ever before in history. Bendix-Pacific is today supplying quality actuators for the industry's latest and most advanced products.

A qualified Sales Engineer is available to discuss your actuator problems.

Write for detailed information.

RADAR | HYDRAULICS | MISSILE GUIDANCE | TELEMETERING | SONAR | ELECTRO-MECHANICAL

Bendix
PACIFIC DIVISION
Bendix Aviation Corporation
NORTH HOLLYWOOD, CALIF.

Bridgeport, Conn. • Dallas, Texas • Dayton, Ohio • Washington, D.C.

FOR MORE INFORMATION CIRCLE 72 ON INQUIRY CARD

NEW TECHNIQUES

ELECTROFORMING:

New Latitude in Design

Improvements in electroforming, a relatively new production technique, now permit this process to be applied to the production of high precision electromechanical components. Previously applied in the manufacture of dies and molds for plastics, it is now used in the production of metal shapes, especially those of tubular, conical or cup-like parts, more economically than by deep-drawing or other operations involving more than a simple swedging or stamping.

Basically the electroforming process is a combination of electroplating and lost wax casting process. It involves the electrodisposition of a layer of metal on a master mandrel and the subsequent removal of the plated shell so that a self-supporting part or formed article, not a mere coating, is produced. In forming complicated shapes that involve undercuts, the mandrels are made of low melting alloys that can be melted out in a hot oil bath. It is in this latter respect that the process resembles the lost wax casting. Major points of differences lie in the fact electroformed interior surfaces achieve highly reflective mirror finishes without polishing; lost wax castings produce an ascast surface. In addition electroforming produces an extremely high degree of density without porosity while casting processes require care to avoid this defect.

High precision parts are now being electroformed from nickel, copper, iron, silver, lead, tin, cadmium, zinc, cobalt, indium, and chromium. One interesting application was the deposition of a relatively thin layer of silver or copper representing a highly conductive metallic media, backed with an exterior casting of a non-conductor resin which achieved lightness in weight and low cost. Although the initial cost of an electroformed part is inherently more expensive than parts produced by normal high production methods, the ability to produce intricate shapes of very pure materials sometimes more than offsets the differential cost in the processes.

S. Fialkoff, Vice President of Camin Laboratories, Inc., Brooklyn, New York, developers of the process, reports that many other applications in addition to those illustrated here will undoubtedly develop for this process since the industry is just beginning to explore the high precision electromechanical components field.

Circle 139 on Reader Inquiry Card

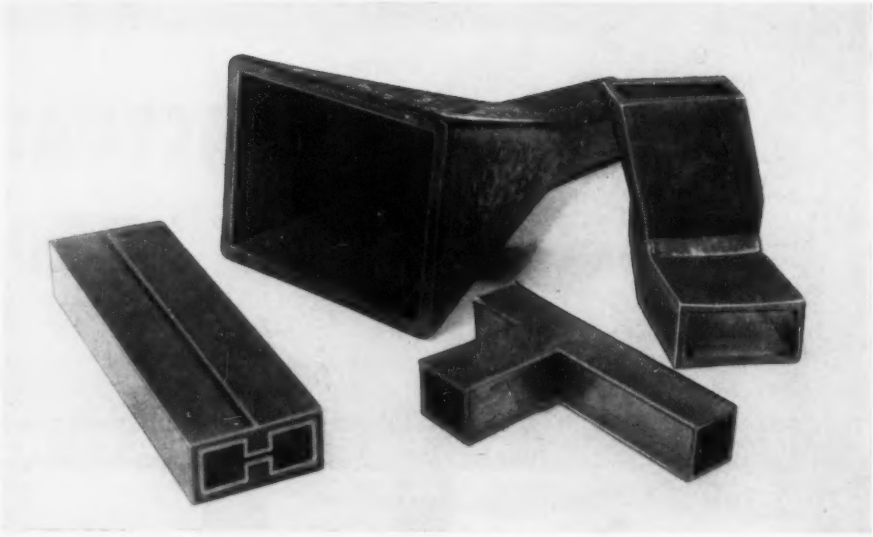


Fig. 2—Laminates of metal can be readily produced in various thicknesses by merely depositing one metal over another to achieve the effect shown above. Procedure is used in producing wave guides and special orifices.

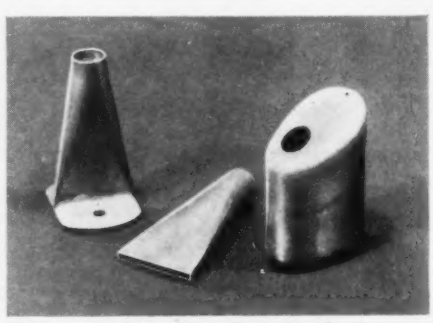
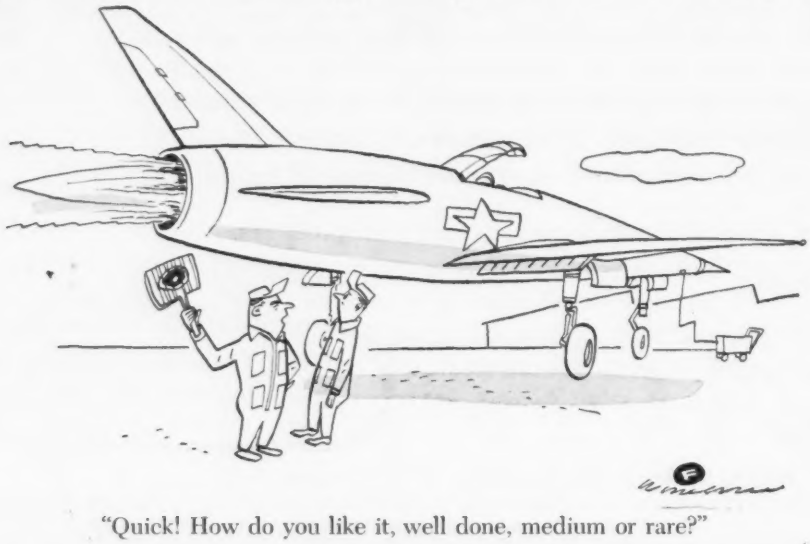


Fig. 1—Instrument float made in one piece with a wall thickness of 0.005" eliminates the need for any welding or soldering operations normally used in joining two halves.

Fig. 3—Pendulum for gyroscopic application was originally made by rolling the tube and the cup together. Concentricity requirements could not be met. In the electro-forming process, a one-piece mandrel incorporating both the tube and the cup produced units with interior dimensions held to 0.0005. Homogeneous distribution of the material throughout the length of the pendulum also was met. (Right): Magnetron cathode support produced by electro-forming process solved the problem of keeping the metal from becoming contaminated during the fabrication process. The extremely high dimensional tolerances for the component resulted in uniformity problems from piece to piece that were extremely expensive if produced by a mechanical process.



"Quick! How do you like it, well done, medium or rare?"

HOWELL MOTOR BRIEFS

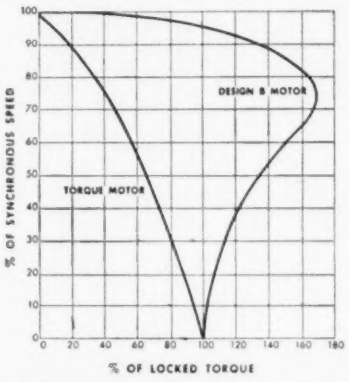
Quick facts for those who apply and specify electric motors

Torque Motors: *They Stall and Hold*

If you want a machine drive to not only apply power but also hold a position or maintain a constant tension, a Howell torque motor may be your solution. Here's a motor that can be stalled, while exerting maximum torque for predetermined intervals, without burning out . . . that can also apply virtually constant torque while operating at a given sub-synchronous speed.

Linear Speed-Torque Curve

The graph below shows this motor's almost linear speed-torque characteristics as compared to a conventional motor's. The secret lies in the design, which produces increased torque while limiting locked rotor current.

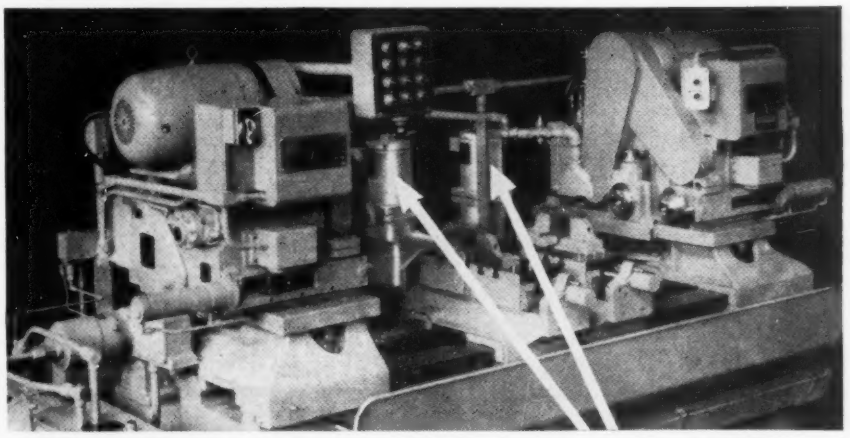


Adaptable to Many Uses

In addition to the clamping, elevator drive and reel tension applications shown at right, Howell torque motors are doing a great many other jobs. Door opening and closing, take-up reeling of film and carbon paper, activating electrical starter contacts and a variety of clutching, chucking and braking operations are among them. They do a quieter, more positive job than many mechanical devices and can often effect important simplifications in machine design.

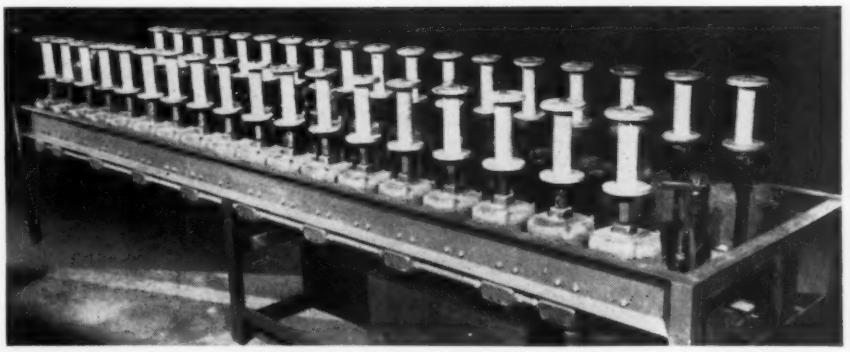
Typical Howell Series 100 Torque Motor

Write to Dept. E, giving details of your requirements. We'll be glad to make suggestions and a quotation.



Two Howell Torque Motors operate clamps for positioning and holding the workpiece on this high-speed, automatic milling and centering machine. Seven Howell motors in all provide power for this precision operation.

A Howell Torque Motor operates the brake and the elevator driving mechanism shown at right. Opening and closing of elevator doors is another typical torque motor application.



A constant, precise tension is maintained on monofilament plastic thread, after extrusion, by the 36 Howell Torque Motors on this winding machine. Multi-speed reeling and winding operations, particularly, are simplified by the use of torque motors in place of geared mechanical devices that are relatively expensive and difficult to keep in adjustment.

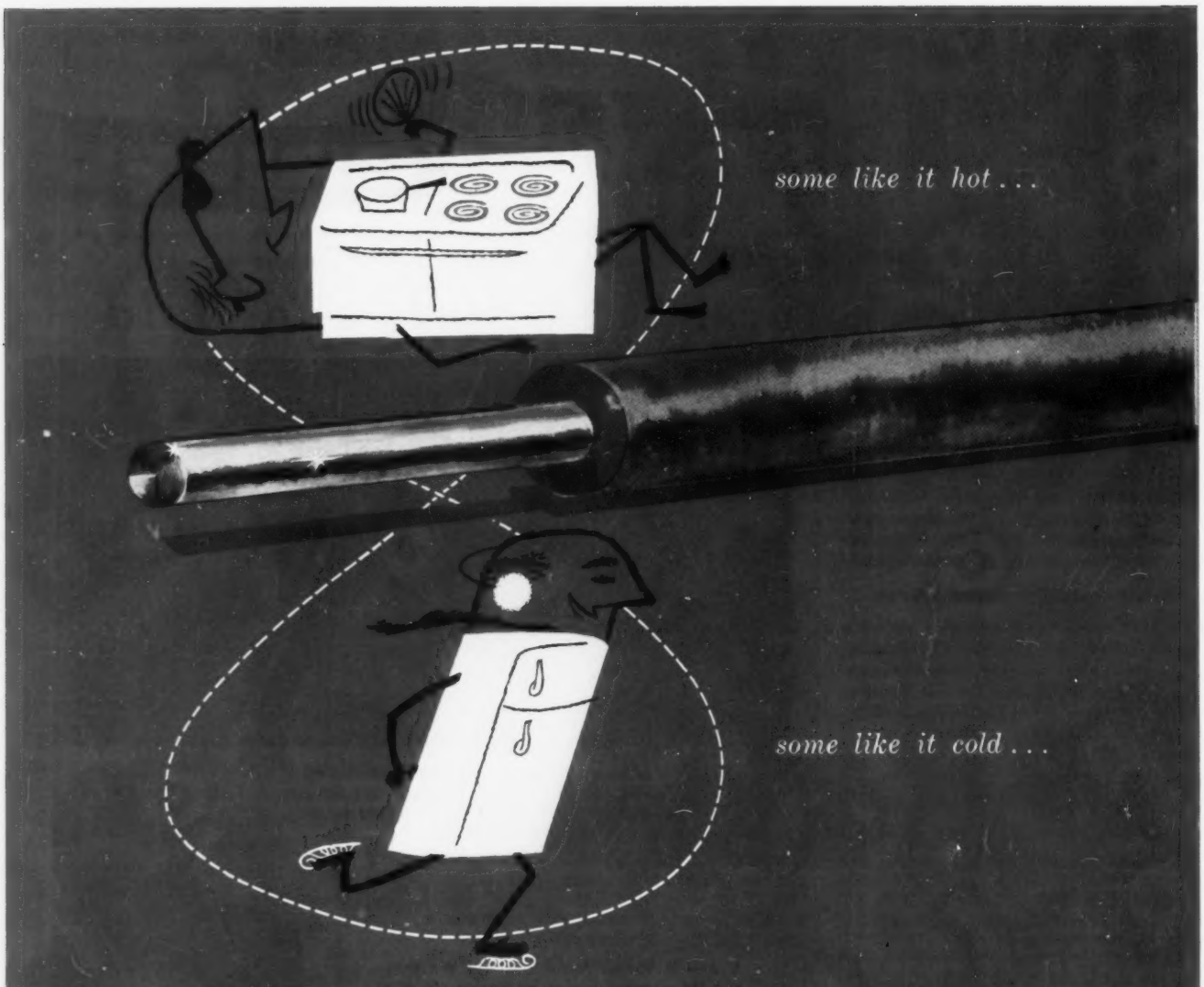
HOWELL RedBand MOTORS

HOWELL MOTORS

HOWELL ELECTRIC MOTORS COMPANY, HOWELL, MICHIGAN

PRECISION-BUILT MOTORS FOR INDUSTRY SINCE 1915

FOR MORE INFORMATION CIRCLE 73 ON INQUIRY CARD



in either hot or cold spots, there's a **CONTINENTAL**

insulated wire or cable that likes it that way

And you'll like the way Continental insulated wires serve your most exacting wiring requirements. There's a wide, wide range of Continental wire and cable — in stock or made to order for your special needs. Write today for the complete catalog of Continental heat and moisture resistant wires and cables.

SILICONE RUBBER INSULATED WIRE

Ideal for appliance wiring where operating temperatures range from −67°F up to 392°F, Continental Silicone Rubber Insulated Wire retains its dielectric and physical properties . . . remains flexible in extreme low temperatures . . . resists weather, flame, fuels, solvents, and oils. Complete data available on request.

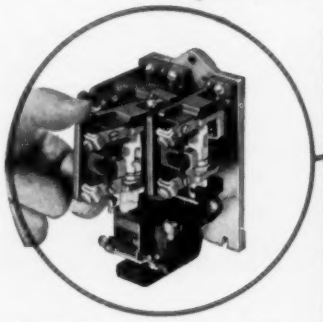
Continental
WIRE CORPORATION

WALLINGFORD, CONNECTICUT • YORK, PENNSYLVANIA

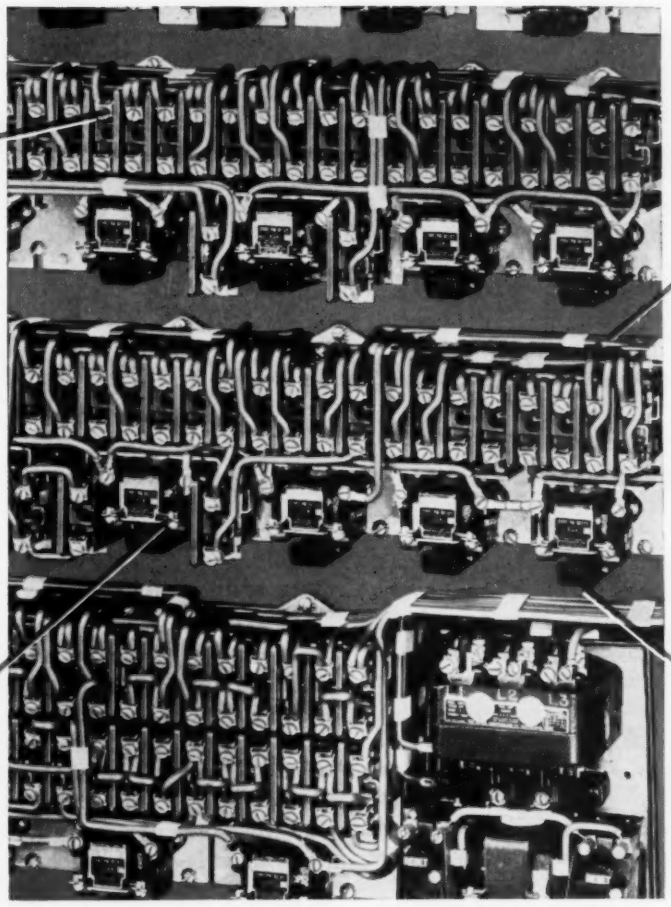
FOR MORE INFORMATION CIRCLE 74 ON INQUIRY CARD

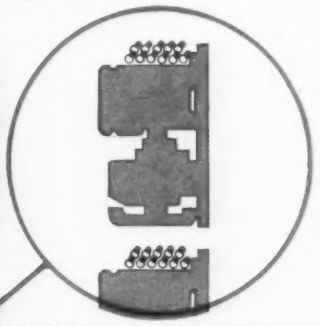
Why CLARK Type "PM" RELAYS give you more contacts per square foot of panel space!

Unique Features Produce Rugged Yet Compact Heavy-Duty Relay...

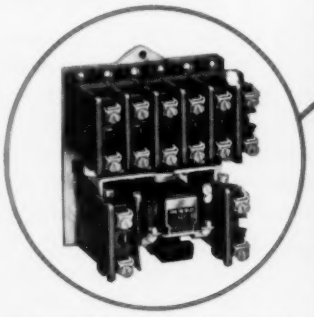


SECTIONAL POLE CONSTRUCTION. A Clark exclusive . . . With each pole in its individual melamine chamber, space between relays for electrical clearance is unnecessary. Front-mounted terminals eliminate need for extra side clearance. Sides of contact blocks are flush with edges of mounting plate.



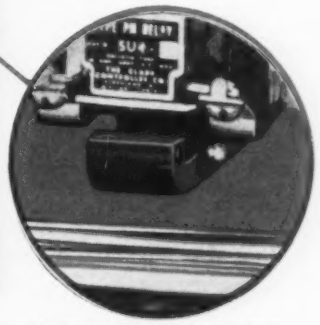


BUILT-IN WIRING SHELF . . . The melamine tops of the pole assemblies provide an insulating shelf free of current-carrying parts. Wiring can be bundled or laid flat right on top of the relay, saving additional space between rows. When wiring troughs are desired, they can be placed much closer to the top of the relay. This feature is another Clark exclusive.

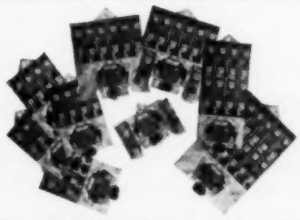


EIGHT-POLE SINGLE DECK . . . Only Clark makes it possible to have an eight-pole relay with single-deck wiring. At the same time, it uses every square inch of space on mounting plate, and lines up perfectly with Clark 2, 3, 4 and 6-pole single deck relays.

UNIFORM DIMENSIONS . . . Clark type "PM" relays are an integrated line designed so that they can be mounted side by side in perfect alignment with each other. In addition, the double-deck models have identical mounting dimensions with Clark type "CY", size 1 starters. Result: Neater, more uniform and more compact control panels.



⅞" MAGNET CLEARANCE . . . That's all the space needed to remove magnet and change coil. In overall panel construction and layout, this feature saves space by reducing amount of space between rows.



FREE TEMPLATES!

FREE TEMPLATES! Write for kit of actual-size photo-templates of type "PM" relays mounted on heavy cardboard. A great time-saver in laying out control panels. Each template has detailed dimension drawing and pole arrangement on the back.

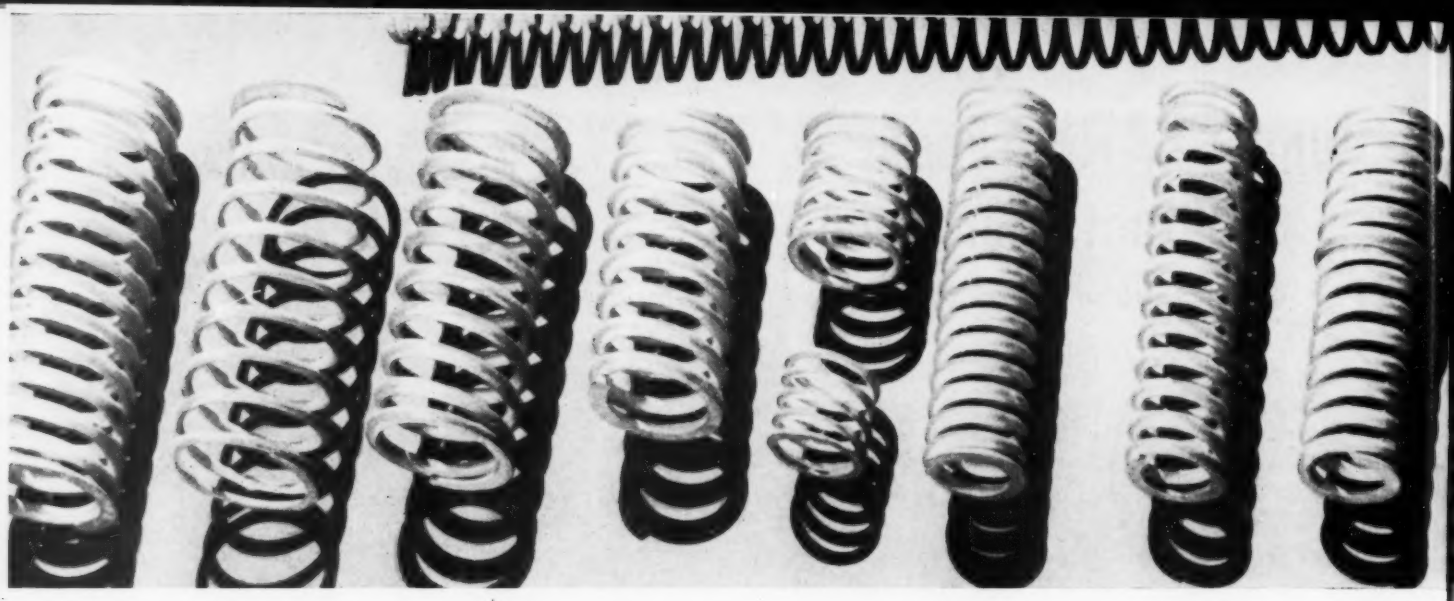
The **CLARK CONTROLLER** *Company*

Everything Under Control

1146 East 152nd Street • • Cleveland 10, Ohio

IN CANADA: CANADIAN CONTROLLERS, LIMITED • MAIN OFFICES AND PLANT, TORONTO

FOR MORE INFORMATION CIRCLE 75 ON INQUIRY CARD



Precision Compression and Extensio

O. G. Meyers and S. L. Albright HUNTER SPRING COMPANY, LANSDALE, PA.

THE helical compression and extension spring are among the simplest and most common elements found in electromechanical devices. Hardly any piece of electrical equipment is so mechanically static that it does not require some kind of spring.

Springs are used to make, hold and break electrical contacts in relays, circuit breakers, and switches of almost every type. They are used as shock mounts for appliances, motors, generators and a variety of other equipment. They are often the most critical components in gages and other precision instruments.

Yet, despite their simplicity and their almost universal use, the successful application of helical springs often requires a disproportionate amount of time, both to design and to troubleshoot. Following these two rules of design will do much to eliminate such problems:

- KNOW THE REQUIREMENTS.
- USE A SIMPLE, LOGICAL, COMPLETE DESIGN PROCEDURE.

This article presents a simplified but complete design procedure for precision round-wire, helical compression springs. A later article will deal with the design of round-wire, close-wound, helical extension springs.

These design procedures are simplified; they use charts and graphs to eliminate tedious calculation; they present a logical step-by-step approach to design. However, this procedure has not been simplified to the extent of neglecting any consideration which effect spring performance in precision applications as do so many so-called "simplified design procedures".

Much of the data in this article applies equally to helical extension springs as to compression springs and can be applied to the extension spring design procedure in the subsequent article. It should be especially noted that different spring charts will appear in each article, but that each one can be applied to both extension and compression spring design procedures presented in the two separate articles.

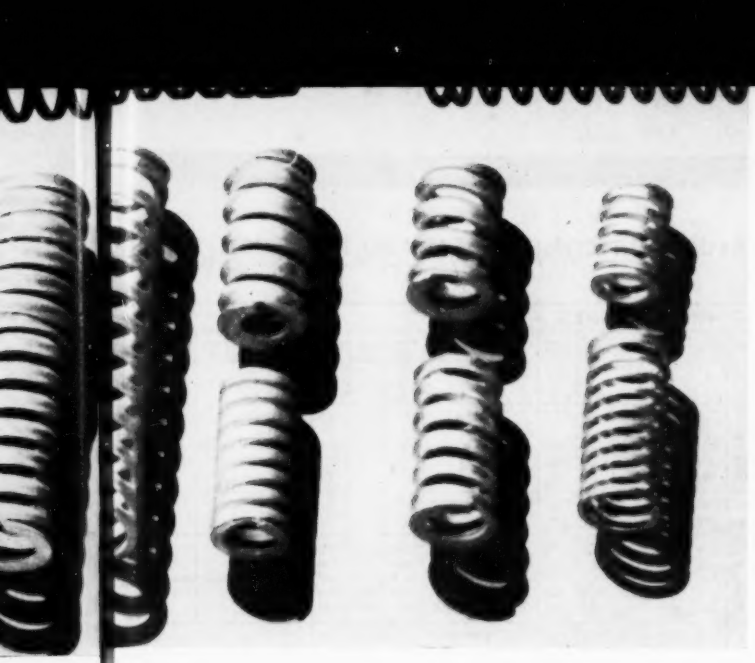
THE SPRING CHART

The design of a spring for any particular requirement involves many factors of varying relative importance. It is, therefore, not practical to derive a formula for the selection of the one correct spring for a given application. It is not a simple case of being confronted with one unknown and a group of definitely known values. It is rather a limited trial-and-error process. To reduce the difficulty of this trial-and-error process, the necessary design calculations have been made for a wide range of practical spring dimensions, and the results recorded in the chart that follows, and in another chart for another class of materials which will be presented in the second article in this series. By scanning these charts, the designer is able to make preliminary estimates of wire sizes and outside diameters for the proposed spring design.

The spring chart is basically a listing of load and deflection values by helix diameter and wire diameter. Each square in the chart represents a unique spring, whose OD and d dimensions are given at the top and along the edge of the chart, respectively. Within the square are given the spring load (P), with the deflection per coil (f) noted below it. The chart describes several hundred individual springs. The number of springs available for one design problem is narrowed by the elimination of unsuitable alternatives, depending on material availability, importance of space restrictions, etc. Once the wire size and the outside diameter are determined, it is a simple matter to calculate the number of active coils, types of ends, etc.

Note that the load carrying capacity of a helical coil spring is independent of the number of turns and the direction of motion (compression or extension). Also, that the load for a given stress (S), is independent of the material used because the modulus (G) does not appear in the formula.

A formula for deflection per coil (f) is derived from the expressions



sion Spring Design

$$S = \frac{8PDR_1}{\pi d^3}$$

$$K = \frac{P}{fN} = \frac{Gd^4}{8D^3N}$$

Solving for P in each expression, equating and solving for yields

$$f = \frac{\pi D^2 S}{GdR_1}$$

Here the values will be different for each spring material because the deflection per coil varies inversely with the modulus (G).

The load given in the chart is the maximum permissible for that combination of wire diameter and helix diameter, for a service life of 50,000 cycles at 0.50 stress ratio. For other conditions, relating to fatigue life, stress ratio, material, types of end, etc., correction factors are provided.

Formulas given in the spring chart permit interpolation tion of P and f values for intermediate coil diameters within the chart. Although the charts are of value in themselves, their greatest use is with an organized spring design procedure.

COMPRESSION SPRING DESIGN PROCEDURE

I. APPLICATION REQUIREMENTS

The spring forces required for any given application can be determined by theoretical calculation, by empirical estimation, by trial-and-error or by direct measurement. Employing one or more of these methods, determine or estimate the initial and/or final loads and consequently the

gradient. If only one load is specified, P_1 is assumed zero and L_1 is assumed to be free length in later calculation.

It is also necessary to make a tentative selection of material before it is possible to start the basic calculations for design. Such considerations as cost, strength and endurance, availability, corrosion resistance, stability at elevated temperatures, and magnetic properties should be evaluated.

II. BASIC SPRING CALCULATION

Referring to the example, the first selection of spring OD and wire size is made in Steps 3 and 4 by turning to the spring chart. When a "corrected load" P_t has been established (using A from Table I), the chart blocks having values P equal to or slightly greater than P_t offer a choice of several springs. From these an optimum OD, based on space limitations, should determine the final choice.

Before the alternative springs are eliminated, it is well to observe that, in later stage of design, any single OD and wire size selected could dictate an undesirable spring length or some other condition calling for a reconsideration of the other possible OD's. To this extent, the design procedure can occasionally lead to a relatively simple trial-and-error process. As the designer becomes more familiar

A—CORRECTION FACTOR for STRESS RANGE, LIFE CYCLES and SPRING MATERIAL

MATERIAL	$\frac{P_2-P_1}{P_2}$	CYCLES				
		5,000	10,000	50,000	100,000	INFINITE
OIL TEMPERED SPRING STEEL	.25	1.23	1.20	1.12	1.09	1.01
	.50	1.18	1.13	1.00	.945	.819
	.75	1.14	1.07	.896	.821	.650
	1.00	1.10	1.01	.800	.710	.500
OIL TEMPERED CHROME VANADIUM AND HARD DRAWN STEEL	.25	1.05	1.02	.955	.927	.859
	.50	.991	.941	.826	.776	.660
	.75	.962	.896	.746	.681	.529
	1.00	.941	.865	.694	.620	.450
OIL TEMPERED CHROME SILICON	.25	1.35	1.32	1.24	1.20	1.11
	.50	1.30	1.24	1.10	1.04	.901
	.75	1.25	1.18	.985	.903	.715
	1.00	1.21	1.11	.880	.781	.550

Table I

U—CORRECTION FACTOR FOR TORSIONAL SHEAR MODULUS.

Oil Tempered Spring Steel	1.0
Hard Drawn Spring Steel	1.0
Oil Tempered Chrome Vanadium	1.0
Oil Tempered Chrome Silicon	1.0

Table II

C—CORRECTION TO N (NO. OF ACTIVE COILS) FOR SOLID HEIGHT CALCULATION.

TYPE OF END	VALUE OF C
SQUARED & GROUND	1.5
SQUARED, NOT GROUND	3
PLAIN ENDS	1
PLAIN ENDS, GROUND	1

Table III

Spring Charts: LOAD AND DEFLECTION VALUES FOR COMPRESSION AND EXTENSION SPRINGS

WIRE DIAM.	OUTSIDE DIAMETER OF SPRING — PREFERRED NUMBERS																																
*d	.240	.260	.280	.300	.320	.340	.360	.380	.400	.450	.500	.550	.600	.650	.700	.750	.800	.850	.900	.950	1.000	1.050	1.100	1.150	1.200	1.250	1.300	1.400	1.500	1.600	1.700	1.800	1.900	2.000
.041	11 53 .0224	10 78 .0278	10 11 .0340	9 494 .0406	8 937 .0478	8 457 .0557	8 013 .0640	7 618 .0729	7 261 .0827	6 490 .1053	5 865 .1306	5 355 .1590	4 929 .1920	4 562 .2537	4 247 .2992	3 973 .3486	3 732 .4017	3 520 .4585	P f														
.0475	17 39 .01095	16 17 .0212	15 23 .0262	14 38 .0316	13 57 .0375	12 85 .0440	12 25 .0511	11 62 .0582	11 08 .0663	9 906 .0883	8 980 .1428	8 083 .1737	7 538 .2086	6 980 .2993	6 504 .3688	6 080 .4253	5 717 .3328	5 391 .3886	5 098 .4315	4 838 .4830	4 606 .5438												
.054		P f	21 38 .0295	20 15 .0245	19 11 .0299	18 18 .0353	17 26 .0411	16 46 .0474	15 73 .0542	14 10 .0728	12 76 .0941	11 68 .1184	10 74 .1453	9 948 .1792	9 260 .2075	8 669 .2430	8 153 .2812	7 687 .3222	7 279 .3663	6 904 .4128	6 576 .4627	6 269 .5149	5 992 .5708	5 740 .6281										
.0625					29 18 .0227	27 63 .0259	26 14 .0314	25 14 .0367	24 10 .0422	21 70 .0575	19 71 .0752	18 03 .0952	16 62 .1177	15 41 .1425	14 34 .1684	13 43 .1989	12 63 .2305	11 91 .2652	11 27 .3019	10 83 .3411	10 19 .3827	9 717 .4266	9 292 .4731	8 906 .5222	8 546 .5734	8 209 .6267	7 907 .6831								
.072							38 89 .0249	37 13 .0281	35 51 .0324	32 22 .0450	29 34 .0595	26 93 .0781	24 87 .0948	23 08 .1154	21 50 .1378	20 16 .1626	18 94 .1843	17 87 .2178	16 91 .2485	16 07 .2815	15 30 .3184	14 55 .3533	13 95 .3922	13 45 .4336	12 84 .4769	12 40 .5221	11 88 .5694	11 06 .6703	10 34 .7794						
.080									47 52 .0283	42 96 .0369	39 36 .0495	36 18 .0637	33 47 .0799	31 09 .0977	29 02 .1174	27 20 .1388	25 59 .1621	24 16 .1871	22 88 .2141	21 72 .2427	20 67 .2731	19 72 .3055	18 88 .3399	17 91 .3757	17 25 .4135	16 68 .4533	16 07 .4952	14 96 .5848	13 99 .6796	13 14 .7830	12 39 .8926				
.0915											56 74 .0384	52 55 .0503	48 72 .0636	45 40 .0785	42 41 .0948	39 75 .1126	37 47 .1322	35 41 .1534	33 54 .1759	31 89 .2002	30 34 .2258	28 96 .2531	27 70 .2819	26 53 .3122	25 49 .3446	24 50 .3788	23 59 .4132	21 97 .4884	20 56 .5701	19 32 .6581	18 22 .7524	17 22 .8515	16 36 .9601			
.0937											60 72 .0367	54 43 .0466	52 03 .0608	48 45 .0751	45 32 .0910	42 56 .1084	40 11 .1273	37 87 .1476	35 88 .1695	34 11 .1928	32 48 .2178	31 00 .2442	29 64 .2721	28 41 .3017	27 27 .3327	26 23 .3654	25 23 .3994	23 51 .4723	22 00 .5514	20 67 .6366	19 49 .7280	18 45 .8260	16 97 .9292	16 66 1.048		
.1055												76 98 .0280	71 31 .0484	66 85 .0686	62 77 .0741	58 97 .0887	55 61 .1046	52 61 .1218	49 87 .1405	47 36 .1602	45 17 .1816	43 14 .2042	41 29 .2281	39 56 .2532	37 98 .2797	36 51 .3075	35 17 .3367	32 77 .3994	30 64 .4668	28 83 .5405	27 19 .6192	25 70 .7075	24 41 .7923	23 23 .8871		
.1205														95 49 .0468	89 86 .0577	84 97 .0699	79 95 .0828	76 03 .1000	72 13 .1127	68 62 .1292	65 47 .1478	62 52 .1656	59 88 .1856	57 46 .2068	55 18 .2282	53 10 .2574	51 11 .2787	47 05 .3290	44 59 .3867	41 88 .4474	39 05 .5148	37 43 .5849	35 21 .6602	33 81 .7405		
.125														105 5 .0435	98 94 .0536	93 38 .0650	88 49 .0775	83 75 .0909	79 61 .1056	75 82 .1213	72 31 .1380	69 09 .1558	66 15 .1747	63 41 .1945	60 97 .2158	58 67 .2380	56 56 .2614	52 67 .3118	49 27 .3649	46 34 .4237	43 71 .4865	41 36 .5530	39 28 .6258	37 39 .7027		
.135															122 0 .0451	114 9 .0560	109 0 .0672	103 7 .0794	98 44 .0923	93 95 .1065	89 60 .1215	85 75 .1376	82 04 .1544	78 78 .1725	75 72 .1916	72 81 .2114	70 23 .2326	68 15 .2775	63 58 .3267	57 57 .3781	54 37 .4365	51 42 .4971	48 82 .5621	46 49 .6316		
.1483																148 0 .0464	139 4 .0555	132 6 .0660	126 4 .0773	120 9 .0897	115 6 .1027	110 5 .1166	106 3 .1316	101 9 .1473	97 83 .1637	94 25 .1813	90 84 .1996	84 72 .2390	79 47 .2823	73 76 .3285	70 38 .3783	66 71 .4324	63 35 .4868	60 30 .5500		
.1562																	161 4 .0503	152 6 .0595	145 4 .0699	139 0 .0812	133 3 .0935	127 6 .1064	122 4 .1201	117 6 .1347	113 1 .1507	108 9 .1664	105 0 .1835	97 97 .2201	91 84 .2602	86 44 .3038	81 55 .3503	77 19 .4003	73 28 .4537	69 80 .5108		
.162																		168 1 .0553	159 7 .0648	152 7 .0755	146 5 .0871	140 5 .0994	134 5 .1121	129 4 .1261	124 6 .1407	120 2 .1564	115 8 .1724	108 1 .2078	101 3 .2458	95 35 .2864	90.00 .3307	85 25 .3784	80 91 .4290	77 05 .4832		
	.900	.950	1.000	1.050	1.100	1.150	1.200	1.250	1.300	1.400	1.500	1.600	1.700	1.800	1.900	2.000	2.100	2.200	2.300	2.400	2.500	2.600	2.700	2.800	2.900	3.000	3.100	3.200	3.300	3.400	3.500	3.600	3.700	3.800
.177	202 3 .0542	192 6 .0631	184 6 .0729	177 4 .0837	170 9 .0953	164 3 .1073	157 9 .1198	152 4 .1335	147 1 .1476	137 6 .1784	129 0 .2117	121 4 .2479	114 7 .2871	108 7 .3294	103 2 .3741	98 22 .4216	93 77 .4726	89 69 .5263	85 92 .5827	79 57 .6195	79 30 .7046	76 37 .7700	73 61 .8379	71 13 .9098	68 77 .9851	66 52 1.061	64 48 1.141	62 52 1.224	60 68 1.310	58 97 1.399	57 30 1.490	55 78 1.586	54 30 1.683	52 90 1.782	
.1875	P f	225 0 .0561	214 9 .0649	205 9 .0743	198 1 .0847	191 4 .0961	184 2 .1076	177 6 .1195	171 5 .1365	160 3 .1688	150 6 .1916	141 9 .2258	134 0 .2689	127 1 .2998	120 8 .3413	114 9 .3854	109 7 .4321	104 9 .4814	100 5 .5332	96 56 .5886	92 88 .6484	89 35 .7061	86 18 .7693	83 18 .8347	80 48 .9040	77 90 .9754	75 50 1.050	73 20 1.126	71 04 1.205	69 02 1.288	67 13 1.373	65 28 1.480	63 60 1.551	61 95 1.644	
.192			228 2 .0616	218 6 .0707	210 5 .0807	202 7 .0912	196 0 .1037	189 3 .1147	182 6 .1271	170 7 1549	160 5 .1829	151 1 .2158	142 7 .2586	135 3 .2981	128 7 .3283	122 6 .3708	116 9 .4150	111 8 .4634	107 2 .5138	102 8 .5668	98 92 .6276	95 24 .6807	91 69 .7418	88 73 .8057	85 76 .8748	83 09 .9417	80 45 1.013	78 06 1.088	75 76 1.164	73 60 1.244	71 57 1.326	69 67 1.412	67 81 1.498	66 13 1.590		
.207				267 5 .0687	247 9 .0802	246 7 .0784	238 4 .0884	230 4 .0991	222 7 .1102	208 6 .1342	196 2 .1672	185 1 .1996	175 0 .2207	165 8 .2540	157 7 .2900	150 2 .3291	143 5 .3698	137 2 .4167	131 5 .4568	126 3 .5046	121 4 .5546	116 9 .6073	112 7 .6629	108 9 .7184	105 3 .7796	101 9 .8414	98 74 .9061	95 79 .9733	93 03 1.043	90 45 1.116	87 86 1.189	85 51 1.266	83 29 1.345	81 20 1.427		
.2187					297 0 .0610	284 7 .0699	273 7 .0786	265 2 .0884	256 5 .0986	241 0 .1208	226 6 .1448	213 8 .1712	202 5 .2008	192 2 .2309	182 1 .2630	174 1 .2990	166 2 .3364	159 1 .3768	152 5 .4178	146 0 .4617	140 7 .5077	135 6 .5565	130 8 .6075	126 3 .6604	122 1 .7151	118 2 .7729	114 5 .8324	111 1 .8944	107 9 .9589	104 8 1.026	101 9 1.094	99 28 1.166	96 60 1.239	94 17 1.314		
.2253						306 4 .0654	295 4 .0738	284 9 .0827	275 5 .0923	259 7 .1136	244 2 .1385	230 4 .1616	218 3 .1890	207 0 .2181	197 0 .2498	187 7 .2831	179 3 .3189	171 5 .3565	164 5 .3966	158 1 .4388	151 9 .4826	146 4 .5292	141 1 .5772	136 2 .6276	131 7 .6803	127 5 .7358	123 5 .7922	119 9 .8521	116 5 .9137	113 1 .9787	110 0 1.188	107 1 1.111	104 3 1.181	101 6 1.253		
.2437								351 7 .0706	339 4 .0788	318 4 .0978	301 4 .1177	284 7 1437	269 1 1630	256 1 1982	243 8 2183	232 6 2483	222 1 2789	212 5 3135	203 9 3493	195 8 3747	188 4 4264	181 7 4682	175 1 5118	169 1 5564	163 6 6040	158 4 6532	153 4 7040	148 8 7575	144 5 8125	139 9 8689	136 1 9290	132 9 9906	129 4 1.052	126 1 1.117		
.250								373 2 .0684	360 8 .0742	338 4 .0916	319 9 .1113	302 9 .1326	287 1 .1557	272 7 .1807	259 7 .2076	247 7 .2363	236 7 .2667	226 8 .2983	217 4 .3333	208 9 .3694	201 0 .4074	193 7 .4474	186 8 .4889	180 4 .5324	174 4 .5775	168 8 .6246	163 6 .6739	158 7 .7252	154 1 .7780	149 7 .8328	145 6 .8897	141 8 .9487	138 1 1.009	134 5 1.071		
.2625										383 9 .0827	362 1 .1005	342 7 .1201	325 9 .1417	309 5 .1647	295 1 .1897	281 5 .2162	269 2 .2446	257 7 .2744	247 3 .3063	237 5 .3397	228 6 .3751	220 4 .4121	212 6 .4509	205 5 .4916	198 7 .5339	192 3 .5777	186 3 .6234	180 6 .6705	175 5 .7201	170 5 .7718	166 0 .8246	161 4 .8787	157 3 .9355	153 3 .9934		
.2812											430 6 .0867	406 2 .1037	387 4 .1231	368 9 .1438	350 2 .1653	336 2 .1899	321 6 .2153	308 3 .2423	295 5 .2705	284 1 .3007	273 6 .3325	263 6 .3656	253 5 .4095	245 0 .4378	238 0 .4756	230 3 .5149	223 3 .5563	216 4 .5986	210 1 .6431	204 1 .6899	198 7 .7378	193 4 .7863	188 4 .8374	183 5 .8895		
.3065												508 8 .0863	479 4 .1023	456 1 .1199	437 3 .1385	418 6 .1603	400 3 .1820	384 0 .2055	368 8 .2304	355 0 .2568	341 6 .2840	329 2 .3131	318 1 .3438	307 1 .3754	297 3 .4089	287 8 .4433	279 1 .4797	271 1 .5177	263 2 .5566	255 6 .5964	248 7 .6304	242 0 .6814	235 7 .7268	229 7 .7721		
.3125												530 4 .0825	501 5 .0977	478 0 .1147	456 8 .1333	438 1 .1535	416 2 .1745	402 0 .1971	385 8 .2209	371 5 .2484	358 0 .2732	345 2 .3012	333 3 .3306	322 0 .3613	311 4 .3933	301 9 .4272	292 8 .4623	284 1 .4987	275 8 .5361	268 0 .5751	260 8 .6157	253 7 .6572	247 3 .7008	240 9 .7448		
.331													578 7 .0861	550 0 .1011	525 3 .1177	504 0 .1359	483 7 .1553	464 3 .1750	445 6 .1972	430 2 .2210	413 7 .2448	399 1 .2703	385 4 .2971	372 6 .3252	360 5 .3544	349 0 .3848	338 4 .4166	328 6 .4499	314 9 .4847	310 3 .5202	302 1 .5575	293 9 .5953	286 2 .6345	279 1 .6757		
.3437														606 6 .0933	578 9 .1087	554 2 .1254	533 1 .1430	512 2 .1632	491 8 .1834	473 5 .2050	455 9 .2276	440 3 .2518	425 4 .2772	411 2 .3034	398 0 .3311	385 6 .3599	373 8 .3898	362 9 .4211	352 7 .4538	342 9 .4875	333 5 .5222	324 7 .5582	316 4 .5956	308 3 .6338		
.3625															657 0 .0962	629 2 .1113	602 3 .1273	580 0 .1450	559 0 .1638	538 7 .1836	519 2 .2043	500 8 .2260	484 4 .2492	468 7 .2735	453 6 .2986	439 3 .3247	426 4 .3524	413 8 .3809	401 8 .4103	390 9 .4413	380 3 .4732	370 5 .5065	360 9 .5406	352 0 .5768		
.375															715 4 .0992	683 1 .1031	654 4 .1181	629 8 .1346	608 5 .1527	585 7 .1710	565 2 .1907	545 3 .2113	527 3 .2331	510 1 .2558	494 3 .2799	479 0 .3047	464 5 .3308	451 4 .3580	438 2 .3857	425 9 .4146	414 7 .4451	403 9 .4765	393 4 .5087	383 9 .5425		
.3938																771 1 .0924	738 1 .1060	708 6 .1207	683 5 .1368	659 4 .1540	637 8 .1723	615 6 .1912	595 0 .2111	576 2 .2321	557 7 .2539	541 6 .2772	525 4 .3011	510 0 .3259	495 4 .3516	482 5 .3791	469 3 .4068	457 0 .4356	445 4 .4655	434 2 .4962		
.4062	*																797 8 .0999	765 5 .1127	737 4 .1278	713 2 .1443	689 6 .1615	665 8 .1794	643 8 .1983	623 3 .2182	604 1 .2391	586 0 .2609	569 3 .2840	552 0 .3072	536 9 .3321	522 0 .3575	508 5 .3843	495 1 .4116	482 5 .4400	470 7 .4695		
.4375																		921 5 .0958	882 8 .1083	848 3 .1218	821 6 .1369	795 5 .1528	771 4 .1697	747 4 .1872	724 4 .2055	702 7 .2245	682 3 .2446	663 9 .2659	645 5 .2876	627 8 .3101	611 3 .3335	595 4 .3577	580 5 .3829	566 1 .4088		
.4687																				1007 .1044	968 8 .1189	936 3 .1385	907 1 .1451	878 7 .1683	855 5 .1770	830 7 .1948	806 7 .2116	784 5 .2301	763 5 .2495	743 4 .2698	723 5 .2901	705 6 .3119	688 2 .3343	671 4 .3574		
.500																					1133 .1011	1098 .1131	1060 .1256	1022 .1391	999 7 .1537	971 4 .1689	946 3 .1850	919 7 .2014	895 2 .2185	871 9 .2366	849 6 .2552	827 5 .2742	808 1 .2945	789 4 .3156		
.5625																									1338 .1187	1299 .1307	1264 .1434	1227 .1563	1198 .1707	1172 .1856	1143 .2012	1114 .2168	1087 .2332	1062 .2501		
.625																												1607 .1258	1559 .1388	1518 .1478	1482 .1684	1448 .1737	1417 .1877	1386 .2010		

*Decimal Equivalent for Washburn and Moen Gauge

MADE OF CARBON AND ALLOY STEELS

OUTSIDE DIAMETER OF SPRING — PREFERRED NUMBERS													BASIC STRESS (S) x 10^{-3}	FORMULAS		WIRE DIAM. d
2.300	2.400	2.500	2.600	2.700	2.800	2.900	3.000	3.100	3.200	3.300	3.400			$P \times DR_1$	$\frac{f \times R_1}{D^2}$	
													112.4	3.042	.7489	.041
													111.2	4.681	.6395	.0475
													110	6.706	.5574	.054
													109.0	10.45	.4764	.0625
													107.6	15.77	.4082	.072
													106.4	21.41	.3633	.080
													105.0	31.59	.3135	.0915
													104.6	33.85	.3050	.0937
													102.8	47.39	.2662	.1055
29.54 1.009	28.35 1.188	27.21 1.299											100.8	69.27	.2285	.1205
32.68 1.560	31.36 1.052	30.12 1.158	29.01 1.253										100.0	76.69	.2185	.125
40.64 .8637	38.99 .9488	37.48 1.038	36.09 1.132	34.78 1.229	33.57 1.331	32.45 1.437							99.0	95.64	.2003	.135
52.70 .7552	50.59 .8388	48.66 .9184	46.85 .9931	45.18 1.068	43.59 1.169	42.13 1.263	40.76 1.368	39.49 1.461					97.2	124.5	.1791	.1483
61.01 .7019	58.56 .7724	56.32 .8466	54.21 .8060	52.27 .9095	50.48 1.009	48.82 1.177	47.23 1.268	45.76 1.363	44.34 1.468	43.05 1.562			96.4	144.4	.1686	.1562
67.31 .6644	64.65 .7320	62.17 .8025	59.89 .8766	57.74 .9535	55.71 1.033	53.87 1.117	52.12 1.203	50.49 1.293	48.96 1.387	47.53 1.483	46.15 1.583		95.6	159.6	.1612	.162
4.100	4.200	4.300	4.400	4.600	4.800	5.000	5.200	5.400	5.600	5.800	6.000					
													93.8	204.3	.1448	.177
													92.6	239.7	.1349	.1875
61.38 1.875													92.0	255.7	.1309	.192
75.43 1.686	73.68 1.778	71.95 1.870	70.36 1.966										90.4	314.8	.1193	.207
87.53 1.556	85.49 1.648	83.55 1.726	81.71 1.815	78.20 1.998									89.0	365.9	.1112	.2187
94.38 1.483	92.26 1.564	90.16 1.646	88.17 1.731	84.45 1.903	80.98 2.093								88.0	395.3	.1067	.2253
117.2 1.324	114.5 1.397	112.0 1.472	109.5 1.549	104.8 1.707	100.5 1.873	96.75 2.052	93.10 2.233						86.4	491.9	.0969	.2437
125.1 1.278	122.1 1.340	119.5 1.412	116.8 1.486	111.9 1.640	107.4 1.801	103.2 1.968	99.38 2.145						85.6	525.4	.0935	.250
142.4 1.179	139.2 1.244	136.1 1.312	131.3 1.388	127.5 1.524	122.4 1.674	117.6 1.831	113.2 1.995	109.2 2.168	105.3 2.344				84.4	599.6	.0878	.2625
170.6 1.053	166.7 1.116	163.0 1.177	159.4 1.239	152.8 1.368	146.6 1.505	141.0 1.648	135.7 1.796	130.7 1.951	126.3 2.114	122.0 2.282	118.1 2.457		82.4	720.0	.0801	.2812
213.7 .9184	208.7 .9713	204.0 1.024	199.6 1.078	191.2 1.193	183.5 1.312	176.5 1.438	170.0 1.571	163.8 1.706	158.2 1.850	152.9 1.998	148.6 2.154		80.0	904.5	.0713	.3065
224.0 .8871	219.0 .9379	213.9 .9886	209.4 1.043	200.5 1.152	192.5 1.268	185.3 1.390	178.2 1.516	171.8 1.649	165.9 1.788	160.3 1.931	154.6 2.082		79.2	949.2	.0692	.3125
259.4 .8054	253.4 .8518	247.9 .8988	242.5 .9472	232.3 1.048	223.0 1.154	214.4 1.265	206.5 1.382	199.1 1.504	192.2 1.638	185.9 1.783	180.0 1.931		77.4	1102	.0639	.331
286.7 .7566	280.0 .7995	273.9 .8445	268.1 .8909	256.6 .9853	246.4 1.086	236.9 1.191	228.2 1.301	220.2 1.417	212.4 1.536	205.3 1.661	198.8 1.792		76.4	1219	.0607	.3437
327.1 .6868	319.7 .7278	312.7 .7698	305.8 .8107	292.9 .8978	281.2 .9899	270.5 1.087	260.5 1.188	251.0 1.293	242.6 1.404	234.5 1.519	227.0 1.639		74.6	1395	.0562	.3625
367.0 .6499	348.9 .6867	340.9 .7258	333.6 .7651	319.5 .8475	307.0 .9354	295.0 1.026	284.3 1.123	274.0 1.223	264.7 1.328	255.8 1.437	247.7 1.550		73.6	1524	.0536	.375
404.3 .5931	394.7 .6293	386.2 .6657	372.4 .7021	361.8 .7787	347.6 .8598	334.0 .9438	321.8 1.033	310.3 1.126	299.7 1.223	289.7 1.324	280.4 1.429		72.1	1729	.0500	.3938
438.1 .5634	428.4 .5969	418.4 .6304	409.7 .6661	392.3 .7384	376.7 .8155	362.6 .8969	349.0 .9811	336.8 1.069	325.0 1.162	315.8 1.258	304.2 1.358		71.2	1877	.0479	.4062
527.3 .4910	515.4 .5215	504.2 .5519	493.6 .5834	472.8 .6477	453.9 .7158	436.6 .7877	420.5 .8620	405.7 .9410	391.7 1.024	378.5 1.109	366.5 1.198		69.0	2269	.0431	.4375
625.3 .4218	611.1 .4570	597.7 .4939	584.9 .5317	561.4 .5899	539.2 .6507	518.5 .8945	499.2 .7612	481.5 .8312	465.2 .9048	449.7 .9811	435.4 1.061		66.8	2702	.0389	.4687
735.0 .3615	718.7 .4058	703.3 .4293	688.1 .4541	660.1 .5062	634.3 .5610	610.3 .6187	588.3 .6795	567.3 .7425	547.9 .8085	529.5 .8770	512.5 .9487		65.0	3191	.0355	.500
991.0 .3018	970.2 .3243	950.4 .3446	930.2 .3651	886.7 .4079	857.9 .4534	826.2 .5014	795.9 .5514	768.2 .6040	742.2 .6590	718.1 .7166	695.3 .7768		62.2	4348	.0302	.5625
1316 .2461	1298 .2645	1271 .2817	1219 .2987	1171 .3349	1126 .3734	1085 .4138	1046 .4562	1010 .5007	975.5 .5472	944.2 .5961	914.5 .6478		60.0	5751	.0262	.625

DESIGN TIME SAVER

with the procedure, his foresight and ability to make simple mental calculations will help him to select correctly the OD and wire size (with related deflection-per-coil f) on the first attempt.

The chart areas left blank represent values of spring index that would be of little general interest, or impractical to manufacture. When possible, it is advisable to avoid the fringe areas of the chart.

The load P is that taken from the spring chart—a value equal to or just greater than the required P_t. Directly below it in the chart block, is the deflection per coil, f in inches, to be used later in calculating length. At the far right of the chart is the basic stress S in thousands of pounds per square inch. The factor U—correcting for torsional shear modulus of the material—is given in Table II.

The solid height is calculated in Steps 5-7 in the example from values recorded in Step 4 and entered as a part of the spring specification. This value will depend upon the type of ends selected according to solid height factor C in Table III.

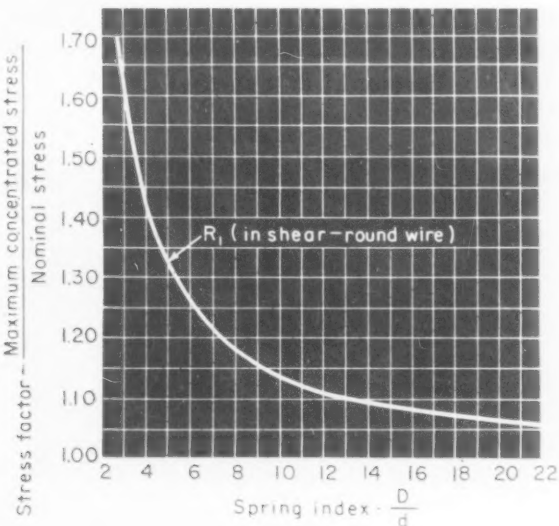
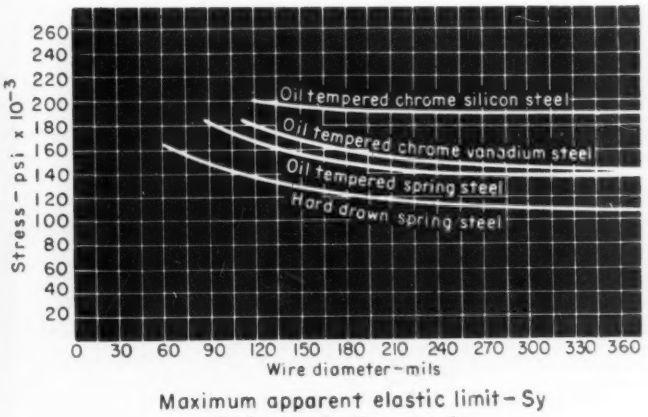


Fig. 1



Maximum apparent elastic limit – Sy
Carbon and alloy steels

Fig. 2

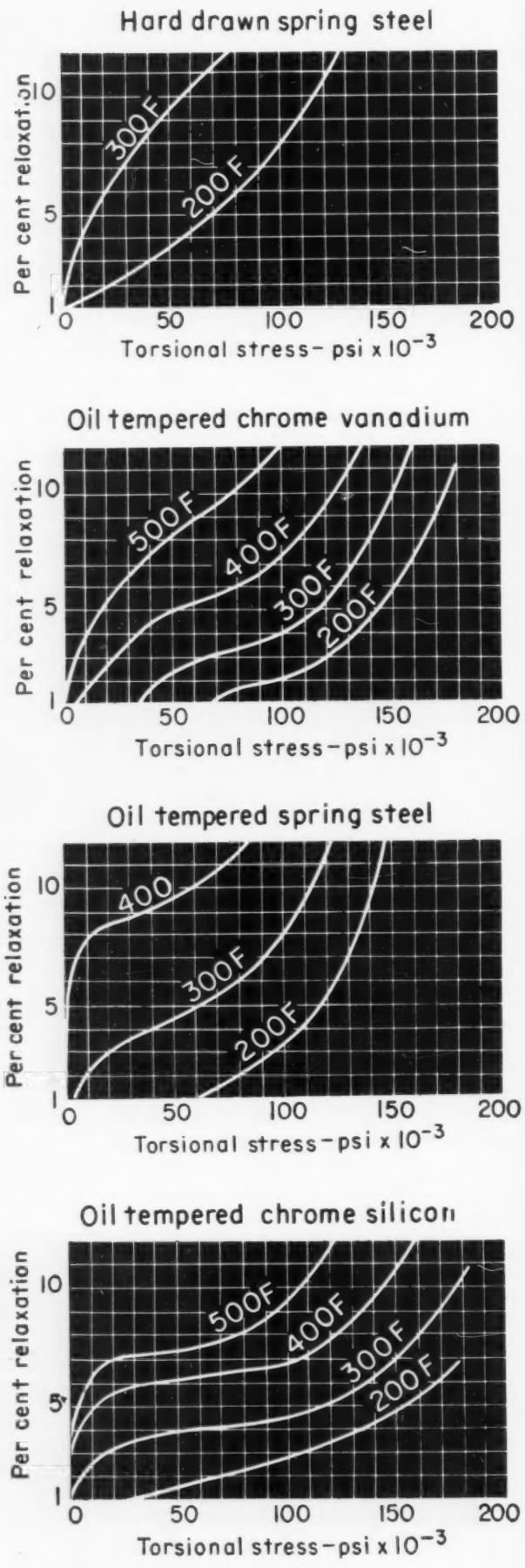


Fig. 3—Effect of elevated temperatures on helical spring.

In Step 8, length at final load is given as a function of the final load and gradient specified, and the specified maximum solid height. At this point the length L_2 should be specified. It cannot be less than the trial length calculated and not less than the specified maximum solid height. L_2 should be close to the trial value, as excessive length may lead to instability or possible permanent deformation if compressed solid. Step 9 leads to the value for length at initial load. If only one load is specified, L_1 is taken to equal free length, and L_2 the length at the specified load.

III. STRESS

If properly followed, the design procedure takes all stresses into account, preventing design for operation at unsafe stresses unless one of the following conditions resulting from deformation in handling and high temperature operation is encountered.

Though properly designed for its service requirements, a compression spring once compressed to solid height may suddenly become an entirely different spring and totally unfit for its normal operation. For this reason S_h must be calculated using Wahl's stress concentration factor (R_1) from Fig 1, even if solid height is not a condition of normal service. The value should be compared to known safe values of maximum apparent elastic limit in Fig 2.

When temperature greatly exceeds normal indoor temperature, then a danger of permanent relaxation exists. The amount of this relaxation should be determined for the highest stress encountered from the data in Fig. 3. If the predicted relaxation is not tolerable when applied to the load, then a spring of higher equivalent load P should be selected from the chart.

IV. VARIATIONS AND LIMITS

An important fact to remember in specifying tolerances is that they must be bilateral—that is, allowing similar variation both above and below the specified value. Otherwise a contradictory specification will result and must be reconciled before a spring manufacturer can conscientiously propose a price.

The normal manufacturing coil diameter variation (ΔD in Fig 4) represents the ultimate process capability. Normally over-all tolerance of $1.6\Delta D$ should be allowed in specifying OD and ID of compression springs. This figure allows for gradient correction in the manufacturing process.

Normal free length variation (ΔH) can be determined from Fig 5. Variations indicated are those within the process capability. A critical free length requirement is rarely advisable or necessary, and would prohibit holding tolerances on the test lengths.

Gradient variation is likewise not often critical. Various means of improving upon the indicated limits as calculated from Table V are available at higher cost. They include varying of the wire section through centerless grinding or selective inspection and discarding.

Initial and final load variations ΔP_1 and ΔP_2 are also calculated from data in Table IV. These are based on the known capabilities of spring-winding machinery. They can be improved, at additional cost, through 100% inspection and segregation or corrective operations.

Squareness tolerances are found in Fig 6 for the free position only. They can be further improved—where cost justifies—through special grinding techniques.

DESIGN TIME SAVER

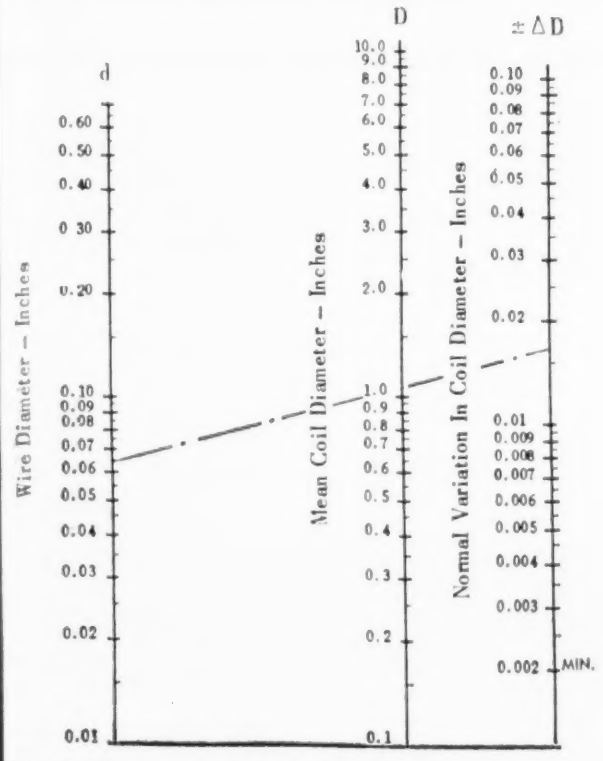


Fig. 4—Nomograph for determining ΔD, manufacturing variation in coil diameter of helical springs.

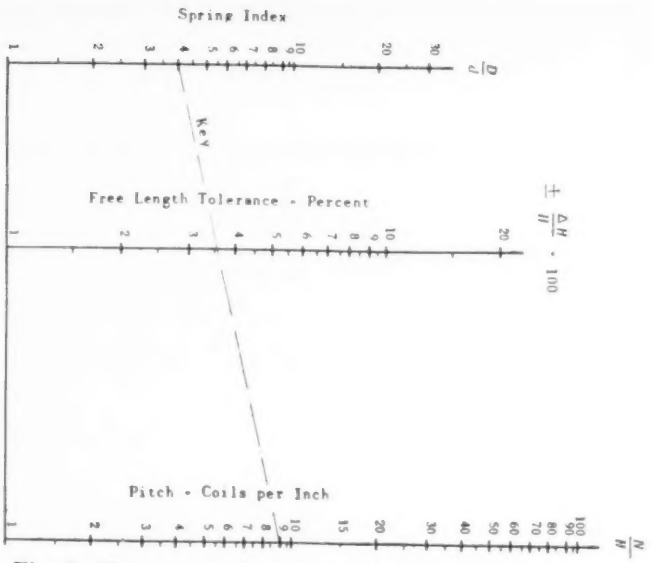


Fig. 5—Nomograph for determining ΔH, manufacturing variation in free length tolerances of compression and open-wound extension springs.

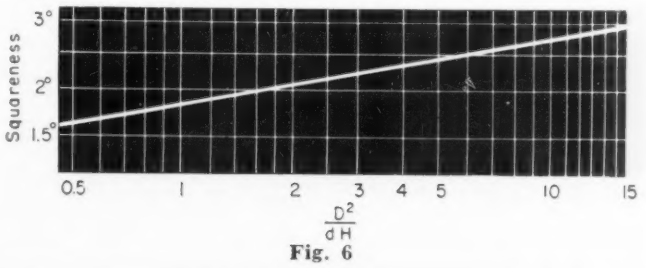


Fig. 6

Wire Dia. d	$X = \left(\frac{4\Delta d}{d} \cdot 100\right)^2$ Music Wire & Stainless	Carbon & Alloy Steels	Copper & Nickel Alloys
.008	48		20
.009	42		19
.010	36		19
.011	32		18
.012	28		
.013	26		17
.014	24		16
.016	20		16
.018	17		15
.020	15		15
.022	13		
.023			14
.024	12		
.025			13
.026	11		
.029	9		13
.031	9		
.032			12
.033	8		
.035	7		
.036			12
.037	7		
.039	6		
.040			11
.041	6	16	
.043	6		
.045	5		11
.047	5	13	
.049	5		
.051	5		10
.054		11	
.055	4		
.057			10
.059	4		
.063	3.5	9	
.064			10
.067	3.3		
.071	3.0		
.072		8	9
.075	2.8		
.080	2.6	7	9
.085	2.4		
.090	2.2		
.091		6	8
.093		6	
.095	2.1		
.100	2.0		
.102			8
.106	1.8	5.0	

Wire Dia. d	$X = \left(\frac{4\Delta d}{d} \cdot 100\right)^2$ Music Wire & Stainless	Carbon & Alloy Steels	Copper & Nickel Alloys
.112	1.7		
.114			8
.118	1.6		
.120		5	
.125	1.5	4	8
.128			8
.130	1.4		
.135		4	
.138	1.3		
.144			7
.146	1.2		
.148		3.3	
.154	1.1		
.156		3.2	
.162	1.1	3.0	7
.170	1.0		
.177		2.7	
.180	0.9		7
.182			
.187	0.9	2.5	
.192		2.5	
.204			6
.207	0.8	2.3	
.218		2.1	
.225		2.0	
.229			6
.244		1.8	
.250		1.8	
.258			6
.262		1.7	
.281		1.6	
.289			6
.306		1.4	
.312		1.4	
.325			5
.331		1.3	
.344		1.2	
.362		1.2	
.365			5
.375		1.1	
.394		1.0	
.406		1.0	
.410			5
.437		0.9	
.460			5
.468		0.8	
.500		0.8	
.562		0.7	
.625		0.6	

No. of Coils N	$Y = \left(\frac{0.2}{N} \cdot 100\right)^2$
1	400
1.5	180
2	100
2.5	63
3	44
3.5	33
4	25
4.5	20
5	16
5.5	13
6	11
6.5	10
7	8
8	6
9	5
10	4
12	2.8
14	2
16	1.5
18	1.2
20	1

Index $\frac{D}{d}$	$Y = \left(\frac{3\Delta D}{D} \cdot 100\right)^2$	$W = \left(\frac{2\Delta D}{D} \cdot 100\right)^2$
3	4	1.8
3.5	4.5	2.1
4	5	2.3
4.5	6	2.7
5	6.5	2.9
5.5	7	3.2
6	8	3.5
6.5	9	4
7	9	4
7.5	10	4.5
8	11	5
8.5	11	5
9	12	5.5
9.5	13	5.5
10	13	6
10.5	14	6
11	15	6.5
11.5	15	7
12	16	7
12.5	17	7
13	17	8
13.5	18	8
14	19	8
14.5	19	9
15	20	9
16	21	9
17	23	10
18	24	11
19	25	11
20	27	12

Table V

FOR CALCULATING

FACTORS "X", "W", AND "V" ΔK

I. REQUIREMENTS

1. Initial load, P_1 . . . . . 200 lbs.
2. Final load, P_2 . . . . . 260 lbs.
3. Gradient, $K = \frac{P_2 - P_1}{F}$ . . . . . 333 lb./in.
4. Material . . . . . O.T. CHROME SILICON
5. Minimum life . . . . . INFINITE cycles

II. BASIC SPRING CALCULATION

1. Stress ratio, $S_r = \frac{P_2 - P_1}{P_2} = \frac{60}{260} = .231$
2. Correction factor, A (Table II) 1.11
3. Corrected load, $P_t = \frac{P_2}{A} = \frac{260}{1.11} = 234$ lb.
4. Tabulated values (See spring charts)
   a. Outside diameter, OD . . . . . 1.400 in.
   b. Load, P . . . . . 241. lbs.
   c. Deflection per coil, f . . . . . .1208 in.
   d. Wire diameter, d . . . . . .2187 in.
   e. Basic stress, S . . . . . 89,000 psi

   Note: If elevated temperature, check steps 4 and 5 under "Stress" before proceeding.

   f. Mean coil diameter, $D = OD - d = 1.181$ in.
   g. Index, $\frac{D}{d} = \frac{OD - d}{d} = \frac{1.4 - .2187}{.2187} = \frac{1.181}{.2187} =$ 5.41
   h. Modulus correction, U (Table III) 1.0
   i. Solid height factor, C (Table IV) . . 1.5
5. Number of active coils, $N = \frac{P}{fK} U = \frac{241}{(.1208)(333)} (1) =$ 6 approx.
6. Plating thickness, τ . . . . . .0003 in.
7. Maximum solid height

CHECK POINT

Calculated $h_{max.} = 1.05d(N+C) + 2\tau(N+2) = 1.7248 = 1.73$ in.

Specified $h_{max.}$ (not less than calculated $h_{max.}$) . . . . . 1.800 in.

8. Length at final load

CHECK POINT

Calculated $L_2 = 1.1h_{max.} + 0.1\frac{P_2}{K}$ = 2.058 in.

Specified L_2 (not less than calculated L_2 and not less than specified h max) 2.125 in.

9. Length at initial load, $L_1 = L_2 + \frac{P_2 - P_1}{K}$ = $2.125 + \frac{60}{333}$ = 2.305 in.

10. Free Length, $H = L_2 + \frac{P_2}{K}$ or $L_1 + \frac{P_1}{K}$ = 2.905 in.

III. STRESS

1. Wahl stress concentration factor, R_1 (Fig. 1) = ... 1.28

2. Total deflection to solid height, $F_h = H - d(N + C)$ = ... 1.265 in.

3. Stress at solid height, $S_h = \frac{F_h KS}{PR_1}$ = $\frac{(1.265)(333)(89.000)}{(241)(1.28)} = 121,500$ psi

CHECK POINT

S_y (Figure 2) = 190,000 psi

S_h must not be greater than S_y.

4. Final torsional stress $S_2 = \frac{S}{R_1} \times \frac{P_2}{P}$ = $\frac{(89.000)(260)}{(1.28)(241)} = 75000$ psi

5. Per cent relaxation at elevated temperature
(See index tab S_{yt}) using S for "Torsional stress" (Fig. 3) = ... 1.0 %

IV. VARIATION AND LIMITS

1. Coil diameter variation, ΔD (Fig. 4) . . . . . ± .010 in.

2. Maximum outside diameter, $OD_{max.} \geqq (D + d) + 1.6\Delta D$ = 1.400 + .016 = 1.416 in.

3. Minimum inside diameter, $ID_{min.} \leqq (D - d) - 1.6\Delta D$ = 0.962 − .016 = .946 in.

4. Pitch, N/H = $\frac{6}{2.905} = 2.07$ coils/in.

5. Free length variation, ΔH (Fig. 5) = .026 (2.905) = ± .076 in.

6. Gradient variation, ΔK (Table V) = $\frac{K}{100}\sqrt{X + W + V}$ (See tab "Tolerances") ± 13.5 lb./in.

7. Initial load variation, $\Delta P_1 = \frac{P_1}{100}\sqrt{\left(\%\,\Delta K\right)^2 + \left(\frac{\Delta H}{H - L_1} \times 100\right)^2}$ . . . . . ± 26.6 lb.

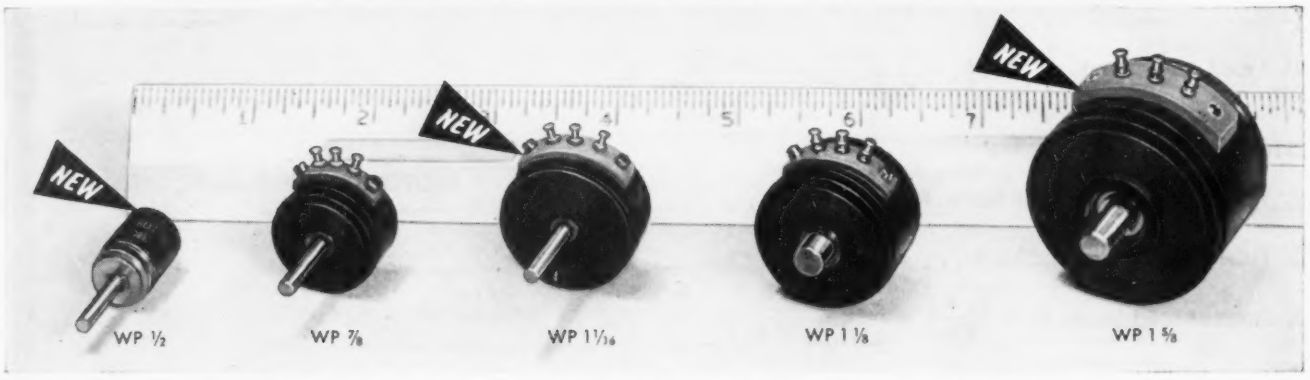
8. Final load variation, $\Delta P_2 = \frac{P_2}{100}\sqrt{\left(\%\,\Delta K\right)^2 + \left(\frac{\Delta H}{H - L_2} \times 100\right)^2}$ . . . . . ± 27.5 lb.

9. Squareness, for squared & ground ends only (Fig. 6) . . . . . ± 2.1 deg.

NOW! A complete single-turn-pot line from *Waters*

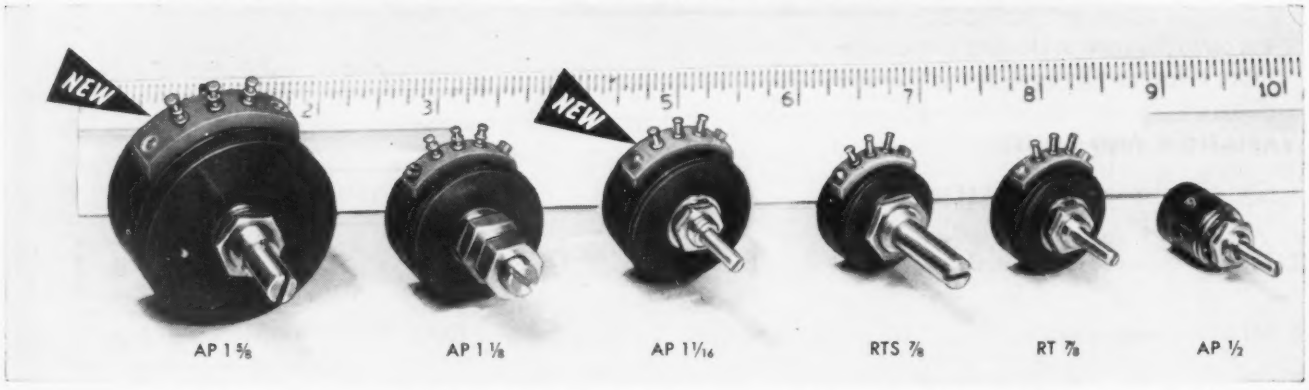
Built, tested, and *certified** to such rigid specifications as AIA, RETMA, JAN-R-19, MIL-E-5272A, and other applicable military specifications, this new line of pots packs reliable performance into tight spots.
**Complete test data available on request.*

Waters PRECISION MINIATURE POTENTIOMETERS



Sizes from ½" to 1⅝" . . . values from ½ ohm to 500K ohms . . . high-precision linear and non-linear . . . write for catalog that describes the complete line.

Waters ROTARY TRIMMER POTENTIOMETERS



. . . include the most compact half-inch pot on the market . . . resistances to 500K . . . non-linear models . . . bushing, servo, or 3-hole mount . . . solder terminals or wire leads . . . write for complete catalog.

Waters LOW-TORQUE PRECISION POTENTIOMETERS

Ball-bearing and jewel-bearing models for ultra-low torque . . . servo or 3-hole mounting . . . solder terminals or wire leads.

Check Waters first for all your single-turn-pot needs.

Big-pot performance in miniature-pot size.

Waters
MANUFACTURING, inc.
MFG. INC.
Wayland, Massachusetts
APPLICATION ENGINEERING OFFICES IN PRINCIPAL CITIES

FOR MORE INFORMATION CIRCLE 76 ON INQUIRY CARD

Three voltage ranges:
0-200, 125-325, 325-525 VDC

1.5 AMPERE MODELS **NEED ONLY 8¾" OF PANEL HEIGHT!**

(metered)		(unmetered)	
MODEL C-1580M:	0-200 VDC, 0-1500 MA....580.00	MODEL C-1580:	0-200 VDC, 0-1500 MA....550.00
MODEL C-1581M:	125-325 VDC, 0-1500 MA....605.00	MODEL C-1581:	125-325 VDC, 0-1500 MA....575.00
MODEL C-1582M:	325-525 VDC, 0-1500 MA....680.00	MODEL C-1582:	325-525 VDC, 0-1500 MA....650.00

800 MA MODELS **NEED ONLY 7" OF PANEL HEIGHT!**

(metered)		(unmetered)	
MODEL C-880M:	0-200 VDC, 0-800 MA....370.00	MODEL C-880:	0-200 VDC, 0-800 MA....340.00
MODEL C-881M:	125-325 VDC, 0-800 MA....345.00	MODEL C-881:	125-325 VDC, 0-800 MA....315.00
MODEL C-882M:	325-525 VDC, 0-800 MA....390.00	MODEL C-882:	325-525 VDC, 0-800 MA....360.00

400 MA MODELS **NEED ONLY 5¼" OF PANEL HEIGHT!**

(metered)		(unmetered)	
MODEL C-480M:	0-200 VDC, 0-400 MA....289.50	MODEL C-480:	0-200 VDC, 0-400 MA....259.50
MODEL C-481M:	125-325 VDC, 0-400 MA....274.50	MODEL C-481:	125-325 VDC, 0-400 MA....244.50
MODEL C-482M:	325-525 VDC, 0-400 MA....289.50	MODEL C-482:	325-525 VDC, 0-400 MA....259.50

200 MA MODELS **NEED ONLY 5¼" OF PANEL HEIGHT!**

(metered)		(unmetered)	
MODEL C-280M:	0-200 VDC, 0-200 MA....214.50	MODEL C-280:	0-200 VDC, 0-200 MA....184.50
MODEL C-281M:	125-325 VDC, 0-200 MA....189.50	MODEL C-281:	125-325 VDC, 0-200 MA....159.50
MODEL C-282M:	325-525 VDC, 0-200 MA....199.50	MODEL C-282:	325-525 VDC, 0-200 MA....169.50

LAMBDA
Electronics Corp.

11-11 131 STREET, COLLEGE POINT 56, NEW YORK

For all power supply needs through 1.5 amperes:

LAMBDA
COM-PAK®
POWER SUPPLIES

Less space! Improved performance!
Long, trouble-free service!
Transient free output!

Fills the need for compact, regulated DC power supplies. Economy of panel space, functional simplicity, new quick-service features.

Wiring, tubes and other components readily accessible. You can reach them easily, service them fast.

400 MA, 800 MA, and 1.5 ampere models include new, high-efficiency, long-life, hermetically-sealed semi-conductor rectifiers. All Com-Pak models are constructed with hermetically-sealed transformers, chokes and capacitors.

Condensed Data

LINE REGULATION ..... Better than 0.15% or 0.3 Volt, whichever is greater.

LOAD REGULATION ..... Better than 0.25% or 0.5 Volt, whichever is greater.

INTERNAL IMPEDANCE

C- 200 Series ..... Less than 6 ohms.
C- 400 Series ..... Less than 3 ohms.
C- 800 Series ..... Less than 1.5 ohms.
C-1500 Series ..... Less than 0.75 ohms.

RIPPLE AND NOISE..... Less than 3 millivolts rms.

POLARITY .... Either positive or negative may be grounded.

AMBIENT TEMPERATURE..... Continuous duty at full load up to 50°C (122°F) ambient.

AC OUTPUT
(unregulated) ..... 6.5 VAC (at 115 VAC Input).

C- 200 Series ..... 10 AMP
C- 400 Series ..... 15 AMP
C- 800 Series ..... 20 AMP
C-1500 Series ..... 30 AMP

AC INPUT .... 105-125 VAC, 50-400 CPS

OVERLOAD PROTECTION.... AC and DC fuses; built-in blown-fuse indicators.

Send for complete **COM-PAK** *data*

LAMBDA Electronics Corporation
11-11 131st Street, College Point 56, New York

By return mail, send complete specifications on Lambda Com-Pak Power Supplies.

Name_____ Title_____

Company_____

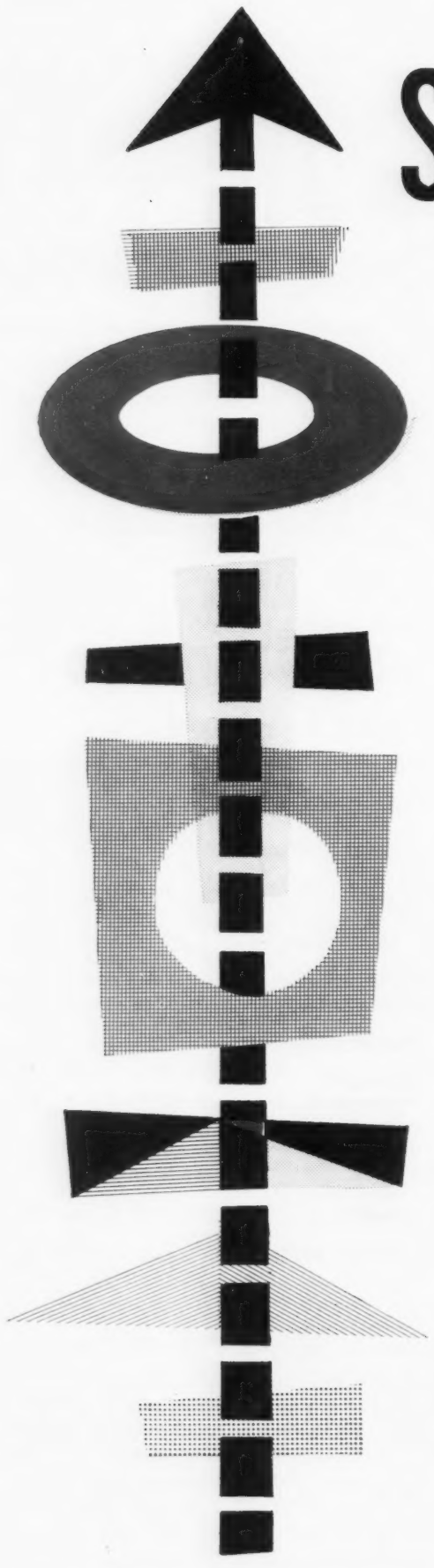
Address_____

City_____ Zone____ State_____

Dept. EMD

RESEARCH

Howard O. McMahon, VICE PRESIDENT, ARTHUR D. LITTLE, INC.



Superconductivity

ITS APPLICATIONS TO ELECTRIC CIRCUITS

It has been known for almost fifty years that certain metals exhibit an abrupt and complete loss of electrical resistance at sufficiently low temperatures. Kammerling Onnes (Leiden Comm., *122b. 124c* 1911; Suppl. *35* 1913) who first observed the phenomenon recognized that he had discovered a completely new state of matter and named it the superconductive state. Since absolutes are rare in nature, it became a matter of considerable interest to determine whether the electrical resistance in the superconductive state is truly zero or only exceedingly small. The most refined experiments carried out to date support the conclusion that the resistance is indeed zero.

Initially it was thought that the superconductive state could be characterized simply by the assumption of perfect conductivity. Applying Ohm's law,

$$E = J/\sigma$$

$E = O$ for σ (electrical conductivity) $= \infty$. Thus the observable properties of superconductors were thought to be adequately summarized by the statement that it is impossible to produce an electrical potential difference inside of a superconductive medium. The magnetic properties of superconcductors would then derive from the consequence of infinite conductivity by applying Maxwell's equation:

$$\text{Curl } E = -(1/C)\ (dB/dt)$$

Since E is zero, the magnetic induction B is constant in time and cannot be altered by any external electrical or magnetic agency. This implies for example that if a superconductor forms a part of an electric circuit, any alteration in current flow can occur only on the surface of the superconductor. It also implies that any alteration in magnetic field would excite suitable persistent surface currents so as to maintain the internal magnetization constant.

In 1933, Meissner and Ochsenfeld (Naturwissens-chapten, *21*, 787 1933) discovered that the superconductive state cannot be described simply in terms of its electrical properties as indicated above. While it is true that the magnetic induction is indeed invariant, they found that B does not have an arbitrary value depending upon the way in which the body was brought in the superconducting state but is exactly zero at all times, a fact which cannot be derived from the criterion of zero electrical resistance. Thus, ideally, the superconductive state is not only infinitely conducting but also perfectly diamagnetic.

Very soon after the discovery of superconductivity, two effects were observed which were not at first recognized to be different manifestations of the same phenomenon.

It was found that the superconductive state is destroyed when a sufficiently strong magnetic field is imposed and it was also found that the normal resistance returns abruptly to a superconductor which is carrying a sufficiently large current. Silsbee (F. Wash. Acad. Sci. *6*, 597 1916) recognized that the latter effect was a consequence of the external magnetic field associated with the supercurrents. It is found that a very

weak magnetic field will restore the resistance to a superconductor when the temperature is only slightly below the critical temperature whereas a stronger field is required at lower temperatures. In general the relation of the required field strength Hc and temperature is approximately parabolic as shown in Fig 1 for a number of known superconductors. Two parameters, H_o the critical magnetic field strength at absolute zero and Tc the transition temperature at zero field strength suffice to define the transition curve for intermediate values of field strength and temperature according to the relation.

$$H_c = H_o\ [1 - (T/T_c)^2]$$

NON-IDEAL BEHAVIOR

Real metals behave like ideal superconductors only in the respect that the electrical resistance is very frequently indeed zero. In all other respects real metals deviate from ideality in a variety of ways and to various degrees depending upon the following parameters:

- chemical inhomogeniety.
- physical inhomogenieties such as crystal boundaries, lattice imperfections, strains, etc.
- size and shape effects.
- extremely high frequency electromagnetic fields.

The non-ideal behavior appears in many ways depending upon the circumstances, but can usually be described in terms of one or more of the following deviations:

- The resistance does not disappear in a discontinuous manner as the temperature is lowered at constant magnetic field strength but is spread over a finite but usually small temperature range.
- The resistance does not change abruptly with changing magnetic field at constant temperature but instead may be spread out over a considerable range of fields and sometimes shows complicated hysteresis effects.
- The Meissner effect (expulsion of magnetic flux when passing into the superconductive state) is frequently quite incomplete, and sometimes almost entirely absent for grossly inhomogeneous specimens.
- There is an apparent failure of Silsbee's hypothesis as indicated from the fact that an imperfect superconductor becomes resistive when carrying a current considerably smaller than that which would be computed from measurements of magnetic field penetration.

It is beyond the scope of this article to examine these imperfections in detail. In general they can be rationalized in terms of an "intermediate state" which is thought to be a coexisting mixture of fibrous superconducting and normal domains. Each small superconducting region is assumed to behave ideally in the sense of being perfectly conducting and perfectly diamagnetic. The existence of inhomogeneities greatly complicates the interpretation of the intermediate state and seems to stablize its existence throughout a comparatively broad range of temperature and magnetic field strength. There are several reference texts available which treat the problem in great detail, D. Shoenberg, "Superconductivity", Cambridge University Press 1952 and F. London, "Superfiuids", Volume 1, John Wiley & Sons, 1059.

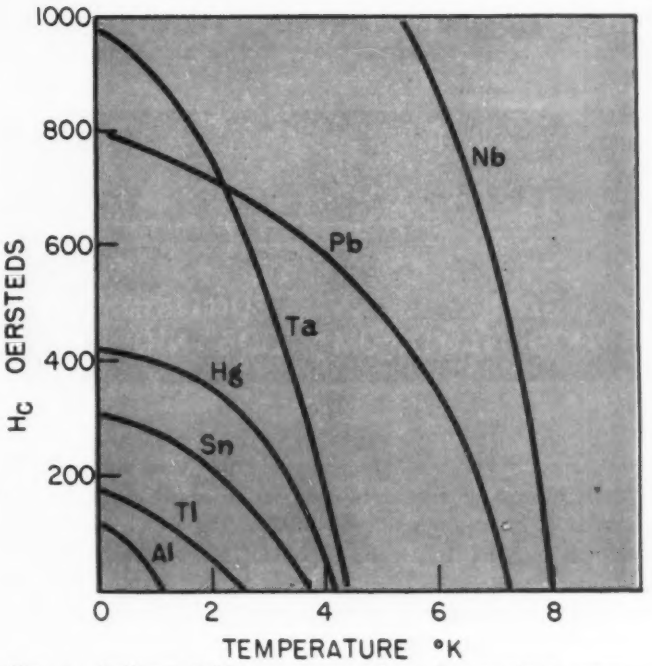


Fig. 1 Critical field vs. temperature for various superconductors

Superconductors as Circuit Components

MAGNETICALLY CONTROLLED CIRCUITS

The first utilization of the sharp resistance change with field strength as a means for switching an electric current was reported by Templeton, ("A Super-conducting Modulator", Jr. of Sci. Inst., 32, 314, 1955). Subsequently, D. Buck, ("The Cryotron—A Superconductive Computer Component", Proceding of the I.R.E., 4, 44, 1956) invented the cryotron, a coil of niobium wire wrapped around a single tantalum wire, and from it constructed a most ingenious bistable circuit device. The niobium control coil conducts a current sufficiently large to restore

Dr. Howard O. McMahon, Vice President and Science Director of Arthur D. Little, Inc., joined the company in 1943 as a member of the Mechanical Engineering Development Group. During the following three years he was responsible for the development of an efficient rectifying column packing which bears his name, a moisture indicator for excessively dry atmospheres, special heat exchangers and the ADL-Collins Helium Cryostat (an apparatus for liquefying helium that is standard equipment for low temperature laboratories around the world.)

But of Dr. McMahon's thirteen patents perhaps the most widely used by everyone is his first patent: the bubbling Christmas tree candle developed while he was still a student.

In 1952 he was appointed Science Director, an office considered to be an innovation in research management. The broad purpose of of the function is to strengthen and integrate the company's scientific techniques and research capability. He was appointed Vice President early in 1956.

This article is based on a paper presented at the Symposium on the Role of Solid State Phenomena in Electric Circuits held at Polytechnic Institute of Brooklyn last April. The original paper will appear in Vol. VII of the Microwave Research Institute Symposia Series to be published in November, 1957.

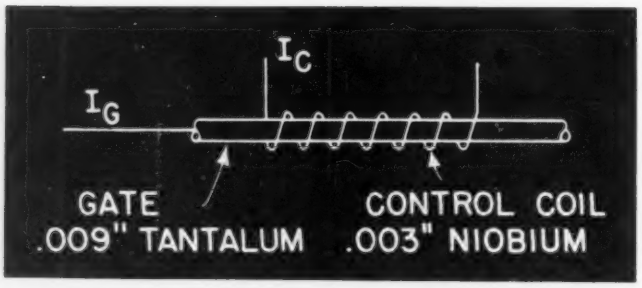


Fig. 2 The cryotron

resistance to the tantalum gate without becoming resistive itself. Moreover, the tantalum gate is capable of carrying a heavier current (while itself remaining superconductive) than is required in a control coil to fully restore resistance to another gate. This combination of circumstances makes it possible to construct a flip-flop circuit (Figure 3) which locks itself into one of two possible conduction modes. Such a device obviously lends itself to the art of computing since it can be readily triggered from one state to the other by adding two more cryotrons and its state can be determined quickly and non-destructively by adding a second pair.

Buck described the device fully and suggested a variety of circuits to carry out many standard logical operations required of vacuum tubes and transistors. A cryotron memory circuit has also been described by A. E. Slade and Howard O. McMahon ("The Cryotron Catalog Memory System", Eastern Joint Computer Conference, December 12, 1956) which utilizes superconducting flip-flops as a binary storage medium. Circuits composed of Cryotron flip flops have an extremely low impedance and are operated from a constant current source. Of all possible current paths only one should be superconductive at a given time. This requirement derives from the fact that for two parallel superconducting circuits the steady state current distribution is indeterminate and in fact has an infinite number of possible values. If the total current is I and the branch currents are i_1 and i_2, the steady state current distribution is given by

$$i_1/I = r_2/(r_1 + r_2) = 0/0$$

which is indeterminate. In any actual branched circuit the final current distribution would be determined by the self inductance L of the individual branches and the mutual inductance M between branch pairs.

To date, interest centers upon circuits which utilize the superconductive transition so as to effect on-off switching; however the cryotron can also serve as a d.c. or low frequency a.c. amplifier. The current gain of such an amplifier is determined by the slope of the R vs. H curve for the particular choice of gate material. If the transition is discontinuously abrupt the gain is infinite. This is never true, however, and as a practical matter the gain is likely to be between 5 and 10. Superconducting amplifiers are under study in our laboratory at present and will be reported upon in the near future.

TEMPERATURE CHANGE AS A CIRCUIT CONTROL

In principle it is possible to utilize a changing temperature instead of a changing magnetic field to effect the superconductive transition and thereby to construct a switching device. There are a number of serious difficulties of a practical nature associated with such a device. The requirement for heat transfer imposes a severe limitation to switching speed. Moreover, it is unattractive to degrade electrical energy into heat at such low temperatures because of the expense of refrigeration. In spite of these difficulties, however, superconductors in the transition state have been used as sensitive bolometers in which the R vs. T transition is utilized.

PERSISTENT CURRENT CIRCUITS

Superconducting circuits consisting of closed loops are capable of carrying a circulating electric current for an indefinitely long period of time with no dissipation of energy. Moreover, the magnitude of the current and its direction is determined by the magnetic history of the loop in a somewhat complicated way. Consider the case of a superconducting ring cooled in a region of zero magnetic field. If it is now exposed to an axial magnetic field H, a circulating current will appear in the ring of such a magnitude and direction as to preserve the initial state of zero flux density within the area encircled by the ring. For a ring of radius r, and assuming the wire to be small in diameter compared to r,

$$L\frac{di}{dt} - \pi r^2\frac{dH}{dt} = iR = O$$

since the resistance R is zero. Integrating this gives the current i.

$$i = (\pi r^2/L)\ (H)$$

When the imposed field reaches a certain value, the vectorial sum of the field caused by the supercurrents and the imposed field becomes equal to the critical field at the outer edge of the ring and begins to restore re-

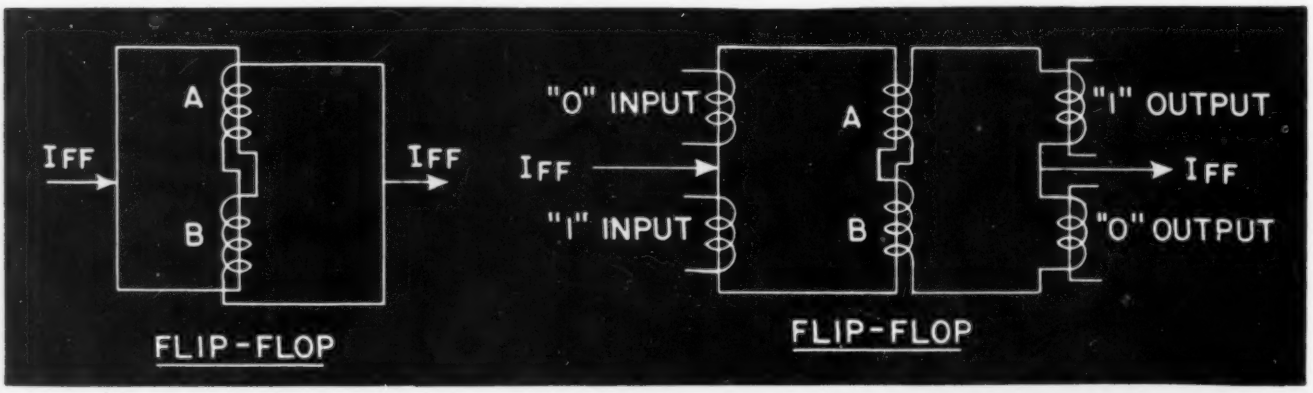


Fig. 3 Flip-flop circuit

For you

CLARAGE FAN COMPANY
619 Porter St., Kalamazoo, Michigan

Please send me literature on:

- ☐ Type NH fans for ventilating, air conditioning, and industrial services
- ☐ Type XL fans for industrial air and material handling
- ☐ Type CI cast iron fans
- ☐ Ready Units—complete, "packaged" fans
- ☐ Service Manual—information adaptable to any air handling job, 68 illustrated pages
- ☐ Unit Heaters
- ☐ Mechanical Draft Equipment
- ☐ Air Conditioning Units, Air Washers, etc.
- ☐ General Catalog

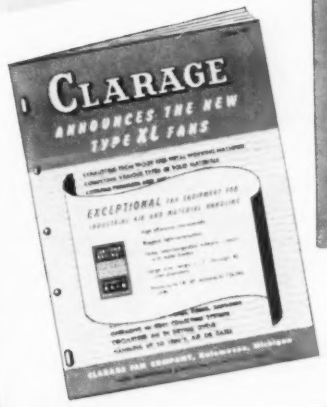
NAME_____

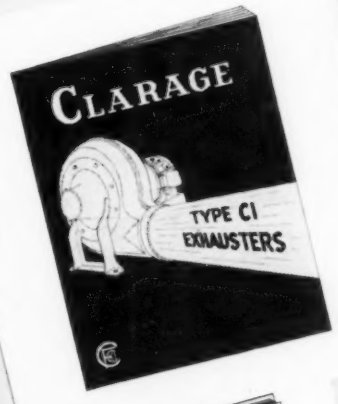
FIRM_____

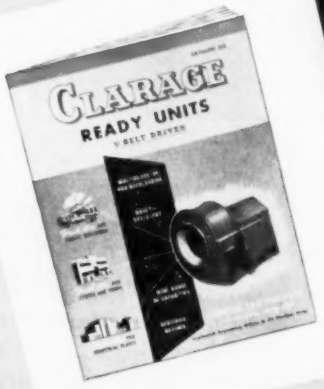
ADDRESS_____

CITY_____ STATE_____

Detailed information on dependable Clarage Fans







These plus other catalogs are available for the asking. Simply use coupon above. Clarage specializes — builds air handling and conditioning equipment exclusively. This concentrated know-how will mean a lot to you regardless of the size or type of your requirements in our field.

CLARAGE

. . . dependable equipment for making air your servant

SALES ENGINEERING OFFICES IN ALL PRINCIPAL CITIES • IN CANADA: Canada Fans, Ltd., 4285 Richelieu St., Montreal

FOR MORE INFORMATION CIRCLE 78 ON INQUIRY CARD

sistance to the ring. At this point the total field at the outer edge of the ring is the sum of two terms. The contribution of the imposed field is 2H because of the demagnetization coefficient of a diamagnetic rod in a transverse field H. Contribution of the circulating current is 4i/d where d is the diameter of the rod. Hence

$$2H + 4i/d = H \text{ critical}$$

As the imposed field is increased further there is a steady decrease in the circulating current so that the vectorial sum of the two fields remains at the value H critical.

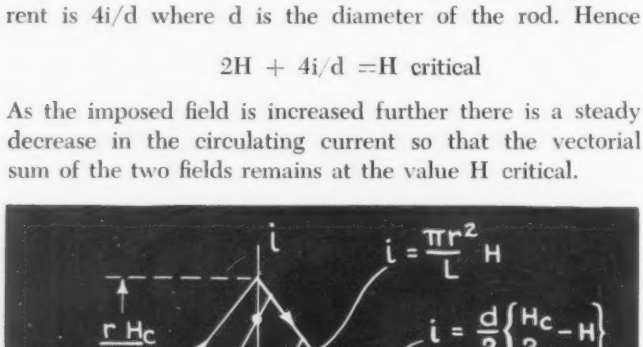


Fig. 4 Hysteresis of current in a closed ring as a function of applied axial field

Fig. 4 shows a hysteresis plot of the current in a closed ring as a function of the applied magnetic field. Boundaries of the diagram are determined by the requirement that the tangential component of the total magnetic field at any point on the surface of the ring must not exceed the critical field. The diagram can be circumscribed only in the clockwise direction. Any change in H which does not intersect the boundary produces a reversible change in i which is completely cancelled when the change in H is reversed. However, if H is changed in such a way as to exceed the diagram boundary the persistent current remaining in the ring when H is returned to its original value is permanently altered and may even have a reversed direction.

With only minor modifications in the shape of the diagram it is possible to substitute magnetization for current along the ordinate and we then have a magnetic hysteresis diagram in which the enclosed area is energy, similar in many respects to the B vs. H hysteresis diagrams characteristic of ferromagnetic materials. As might be supposed, it is possible to construct memories from small superconducting rings which are analogous in many respects to magnetic core memories except that the direction of the stored magnetic field is axial rather than circumferential.

The same general considerations presented above apply to all multiply-connected bodies or circuits In singly-connected bodies, however, such as a sheet or a sphere, the problem is quite different. In general, it is not possible to have closed circulating currents in the absence of an externally applied magnetic field without having some portion of the body in the intermediate or normal state. Since a closed current path always gives rise to magnetic flux which threads the loop, a circulating current in a singly-connected superconducting surface would require the magnetic flux to penetrate the surface somewhere within the loop thereby causing the material to be non-superconductive.

THE SUPERCONDUCTIVE TRANSFORMER

If a primary and secondary circuit are coupled magnetically with a mutual inductance M, a current change in the primary causes an induced current in the secondary according to the usual induction equation

$$L\frac{di_s}{dt} - M\frac{di_p}{dt} = i_s R$$

When R is zero for the secondary circuit, the equation can be integrated directly:

$$i_s = -\frac{M}{L} i_p$$

Thus the secondary circuit current is the integral of all changes which occur in the primary current. A superconductive secondary circuit thereby extends the application of the transformer to d-c circuits.

Principal Problems of Superconductive Circuits

TIME CONSTANTS

Many of the potentially interesting circuit applications for superconductivity, such as the cryotron, depend upon switching a current from one path to another by causing a portion of a superconductive path to become resistive. The time required to accomplish this is directly proportional to L and inversely proportional to R, the resistance in the normal state.

$$T \propto L/R$$

For a cryotron, the resistance of the gate wire is inversely proportional to d^2 where d is the diameter of the gate. If the control wire diameter has a fixed relationship to the gate wire diameter, and if the space between turns has a fixed relationship to diameter, then the self inductance for the coil is independent of d. From this it is clear that the time constant of a cryotron of constant geometry varies as the square of diameter.

$$t \propto L/R \propto (\text{constant}) / (1/d^2) \propto d^2$$

A considerable improvement in speed may therefore be expected from iniaturization. A further improvement is to be gained by selecting as a gate material a metal or alloy which has a high resistivity in the normal state.

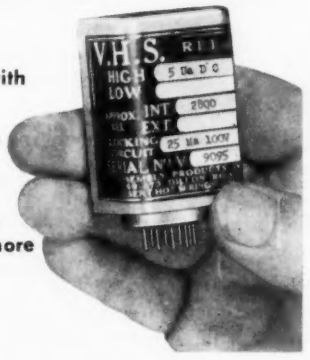
CURRENT DISTRIBUTION PROBLEMS

When current flows in superconductive conductors the current flow is confined to a thin skin on the surface. Moreover, the surface distribution is not uniform except for a cylindrical conductor. In general the distribution is the same as would be obtained in a normal conductor for very high frequency since in both cases the magnetic field is not permitted to enter the conducting medium.

In the case of longitudinal current flow in a thin strip, for example, the current flow is not uniformly distributed across the width of the strip. It would be expected to be concentrated somewhat towards the edges of the strip and the strip behaves more or less as though it were to be replaced by two thin wires. This means that the current-carrying capacity of a wide strip is not proportional to its width. Considerations of this sort are important whenever experiments are planned with superconductive films or foils END

A METER-TYPE VHS

5 MICROAMPERE RELAY



- 2800 ohms
- 0.5 Second response time with 7 microamperes applied
- Operates: −40° to +150°F., 5-55 cycles vibration, 10 G or more
- Survives: −65° to +175° F., 5 to 2000 cycles, 10 G or more
- Hermetic seal
- 1" x 1¼" x 2¼", including terminals

The new model 126 VHS Meter-Relay is smaller than previous models. It has a moving coil armature which rotates in the flux gap of an Alnico magnet. A locking coil in the moving element develops extra torque for positive contact action.

The case is solder sealed and may have a plug-in base or solder connections with hold-down screws.

This meter-relay can be supplied with coils for 0.2 microamperes to 10 amperes or 0.1 millivolts to 500 volts. With internal rectifiers there are similar ranges for AC. Contact arrangements are: single high, single low or double (high and low).

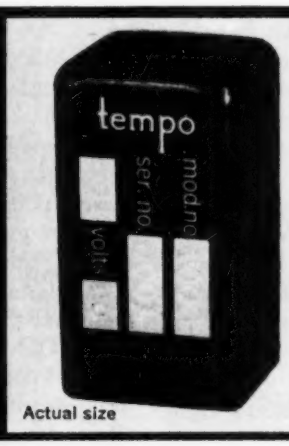
ASSEMBLY PRODUCTS, INC.

P. O. Box XX, Palm Springs 83, California
Telephone: DHS 4-3133 or 4-2453
BOOTH 217, NATL. ELECTRONIC CONFERENCE, OCT. 7-9, HOTEL SHERMAN, CHICAGO
CIRCLE 79 ON INQUIRY CARD

Electronic

TIME DELAY RELAY

Transistorized



Actual size

- Time delay..... .01 to 60 sec.
- Accuracy..... ±10%
- Recycling..... Instantaneous
- Temperature. −55° to +125°C
- Vibration..... 20 g, 2000 cps
- Input..... 18 to 31 VDC
- Contacts..... DPDT, 2 amp
- Life..... 100,000 cycles min.
- Weight..... 2 ounces

AND — 30 day delivery of limited quantities

tempo

TEMPO INSTRUMENT INCORPORATED
240 Old Country Rd., Hicksville, N. Y.

Creating New Concepts in Advanced Electronics

CIRCLE 80 ON INQUIRY CARD

Type MA FOOT SWITCH

Light-weight, fast-operating Foot Switch. Ease of operation assures minimum fatigue. SPDT internal switch is long-life General Control "du.op" Limit Switch. Modern design; attractively finished in grey and red.

Removable end. Access to internal terminals by simply unscrewing front end.

FOOTROL GENERAL CONTROL foot switches — the recognized leaders — for dependable, fast, efficient control. Select from a complete line of foot switches with standard and heavy-duty ratings.

Write for Bulletin FS-200

MA MC MI

FOOT, LEVER, PUSH BUTTON and LIMIT SWITCHES
ELECTRONIC and SYNCHRONOUS–MOTOR TIMERS
CUSTOM CONTROL PANELS

GENERAL CONTROL COMPANY
1199 Soldiers Field Road • • Boston 34, Massachusetts

CIRCLE 81 ON INQUIRY CARD

Write For 32 Page Catalog

- Pump Controls
- Duplex Pump Alternators
- High and Low Level Cutoffs
- High and Low Level Alarms
- Multi-level Signals
- Liquid Metering
- Special Controls and Panels

Listed by Underwriters Laboratories

CHARLES F. WARRICK CO.

1970 W. Eleven Mile Rd.
Berkley, Mich.

Warrick

FLOATLESS
LIQUID LEVEL CONTROLS
ELECTRODE TYPE

CIRCLE 82 ON INQUIRY CARD

STAFF COLUMNIST

Dr. Jesse E. Hobson

Jesse E. Hobson is assistant to the President of the United Fruit Company

ORGANIZING FOR RESEARCH

Scientific research is understood by a great many people to be a great many things. It is as difficult to find a single, unanimous definition of research as it is to find an authoritative description of the Abominable Snowman of Tibet. Fortunately, the results of research are not so elusive. We can measure them by many standards——by production volume, by profits, by new processes and new knowledge, by the abundance and vitality of our economy ——all of which are served by the research method.

The essence of research results is that they provide us with new facts and new information. Facts become the basis for company action to improve its products and its sales, to strengthen its profit position, to prepare for long-range security, to overcome operating difficulties. Facts, the product of research, must come from laboratories and pilot plants, from market analyses and cost studies, from efforts to understand more fully the reactions of customers, employees and shareholders.

The use of research results is an executive function. Management must integrate the research findings of its specialists into the fabric of planning decisions, fiscal decisions and operating decisions. Research facts are not a substitute for management action. Research facts cannot replace management experience or supplant management judgment. But as the processes and operations of industry become increasingly complex and the requirements of management increasingly exact, reliance upon the results of scientific fact-finding must also increase.

In the past generation research appropriations in every industry, in nearly every company, have risen many times over. From an insignificant budget item which received scant and grudging attention a relatively few years ago, company research programs are now adequately if not ideally supported and command the careful consideration of directors and line executives. Staffing for research has become a crucial part of every recruitment program. In our technologically-based economy there is a blue-ribbon premium on creative, experienced, well-trained research brainpower. Investment in research facilities and personnel returns a handsome dividend payable in industrial progress, vigorous economic growth and national security.

The American people, American business, technology and capital will be called upon to perform continuing prodigies to provide swiftly expanding demands for raw material, manufactured goods and consumer items, communications, transportation and services of many kinds. Greater research effort and more skillful use of research results will be the heart and soul of the achievement.

If the achievement is to be realized, however, we must guard closely against taking research results for granted, against overburdening our research resources with too many company fire calls, too many wasteful demands, against looking to research for all the answers.

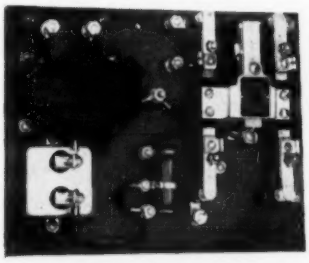
Many times research appears to perform feats of magic. Nothing could be more illusory. Research is hard work. It requires painstaking effort, sound training and education, substantial investment and resourceful administration. Above all, its results cannot be commanded to appear, genie-like, in response to arbitrary timetables or to satisfy unrealistic ambitions. While there is probably no problem in physical or economic realms which is forever immune to an organized, well-conceived research effort, there are still formidable barriers to the solution of old and new problems. They will be solved, no doubt. They will be solved by increased research investment —which we know must come from identifiable sources of capital; by better trained, more resourceful personnel— which we know will be the product of improved social and educational environment; by better-conceived, better organized, more responsive research programs—which must come from the research community itself.

Organization for maximum research results is one of the profession's most basic challenges. Over the past generation we have been caught up in the swirl of war, cold war and a booming mid-century economy without much opportunity for a pause to consider how research can be organized and planned to take maximum advantage of the rich resources available all across the spectrum of physical and human knowledge. Research is today predominantly organized along vertical lines; individual companies, some entire industries and many of our fine service organizations provide but a single or limited type of internal professional research service to meet specific, restricted objectives. There is no longer a question of selling research to industry—that day is long past—but there is a need for experienced research scientists to supplant industry's own internal research organizations.

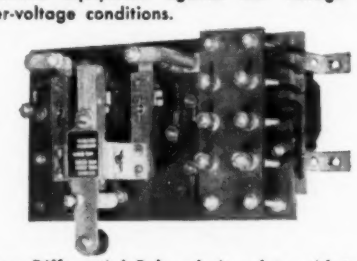
The problems of industry are becoming and will become more horizontal. Only in rare and isolated cases will a research problem come in a neat package easily ticketed to a specialized cubbyhole for solution. Interdependence is a concept for enlightened research as much as it is for suburban social life or international diplomacy. Few research problems can be confined to a single specialist's laboratory. Almost all research results, if they are to be applied successfully, have aspects of economic, markets, operations research, public relations, personnel, etc., which require teams of experts representing competence in fields of the physical sciences, economics, the human and perhaps the biological sciences. Only by mutual exchange and use of information from several fields can research be assured of the most effective employment of its efforts.

Research service must be organized on a broad base from which it can draw on a whole range of skills from engineering to public relations, from accounting to chemistry. Such a reorganization of research—specialized laboratories in the physical sciences and engineering supplemented by outside research services and consultants in economics, marketing and psychology—will provide pools of proven professionel brainpower to serve the many requirements of business, industry and government. It should be given high priority at industrial and research council tables throughout the country.

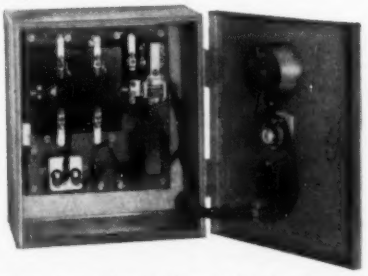
ASCO close differential relays respond crisply to 2% voltage or current variations... with no chattering on pickup or dropout.



Voltage Type Close Differential Relay protects electrical equipment against low voltage or over-voltage conditions.



Close Differential Relay designed to withstand NAVY Hi-shock requirements. Has tapped transformer making the relay suitable for a series of different pickup and dropout voltages.



Current type Close Differential Relay Panel for process control. (Relay operates as a function of motor load current.) Has adjustable pickup and dropout control. Panel has been used successfully for controlling cotton baling equipment.

ASCO Close Differential Relays (available either A-C or D-C) have been developed to meet the demand for a unit having the ruggedness of a power relay yet retaining the sensitivity of a primary control relay.

FEATURES

• Positive action on make or break, with no tendency to creep on opening or closing • 2% Sensitivity • Wide Variety of Applications • Available in Various Pole Combinations Up To 2 Normally Open and 2 Normally Closed Poles • Continuously Adjustable Pickup, or Variable Pickup By Tap Changing is Available • Continuous Dropout Adjustment is Standard.

MODIFIED ARRANGEMENTS

• High Shock Design • Variable Pickup • Frequency Response • Delayed Action • D-C Relays Also Available.

APPLICATIONS

As Voltage Relays they are extensively used in power and lighting systems to protect electrical equipment against low voltage or over-voltage conditions. For example . . . they permit detection where motor feedback conditions would not permit detection by ordinary potential relays. These relays are regularly furnished with ASCO Transfer Switches to provide voltage supervision of single phase and polyphase systems.

As Current Relays they have found extensive application as off-peak load relays to automatically disconnect selected loads, preventing system loading beyond set values. Close differential detection makes ASCO Close Differential Relays ideal for process control by motor current measurements.

Close Differential Relays are only part of the complete line of Relays offered by ASCO. ASCO Catalog 57-S4 lists:

- MAGNETICALLY HELD RELAYS
  AC or DC . . . Normally Open . . . Normally Closed . . . Double Throw
- MECHANICALLY HELD RELAYS
  AC or DC . . . All pole combinations
- SPECIALIZED RELAYS, INCLUDING:
  . . . Reverse Current
  . . . Time Delay
  . . . Brake Winding Time Delay
  . . . Close Differential
  . . . Current Type, Welding
  . . . Electronic
  . . . Modified Arrangements

Write for your copy of "Relays by ASCO"— Catalog 57-S4.

Automatic Switch Co.
1 Hanover Road, Florham Park, New Jersey
FRontier 7-4600

ASCO®

FOR MORE INFORMATION CIRCLE 83 ON INQUIRY CARD

TRANSITIONS

From Engineer to Supervisor

Within the past year some question has been raised as to whether an engineering shortage does or does not exist. But no authority appears to question the shortage of engineering supervisors. To meet this need more and more engineering organizations have begun to develop supervisors from within their ranks of engineers wherever possible. H. M. Elliott of RCA spelled out some of the steps in the transition from engineer to supervisor and some of the danger areas in a paper presented at WESCON. To Elliott, the function of supervision is to know what to do first before working out the details of how to do it

DREAMS OF GLORY: THE PRESIDENCY

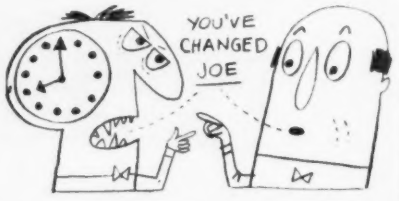
What does an engineer have to know to be a good supervisor? Elliott believes that he must be competent in his field; he must acquire specific knowledge in techniques pertaining to performance of his job and the operation of the company. Most important, he must broaden his perspective and learn to think as one who directs the activities of others. Elliott believes that this is a subtle change and consequently requires guidance on the part of more experienced personnel. During the transition period, occurring both before and after the actual promotion, this guidance is extremely important since it is during this time that the characteristics of the man as a supervisor are set.

Elliott points up this critical period in the transition, the time when ideas and attitudes are formed and solidified. "At first there well may be confusion in the trainee's mind. It is not uncommon for the trainee, mentally, to swing between two extremes. On the one hand, flushed with success and pride of having taken the first step up the company's ladder, he has visions of becoming President—of the company, at least—and may possibly act accordingly. On the other hand, suddenly concerned with the many matters that a short while ago he had nothing to do with or was even unaware of, he thinks he must have been out of his mind for ever agreeing to get into such a rat-race, and again may act accordingly."

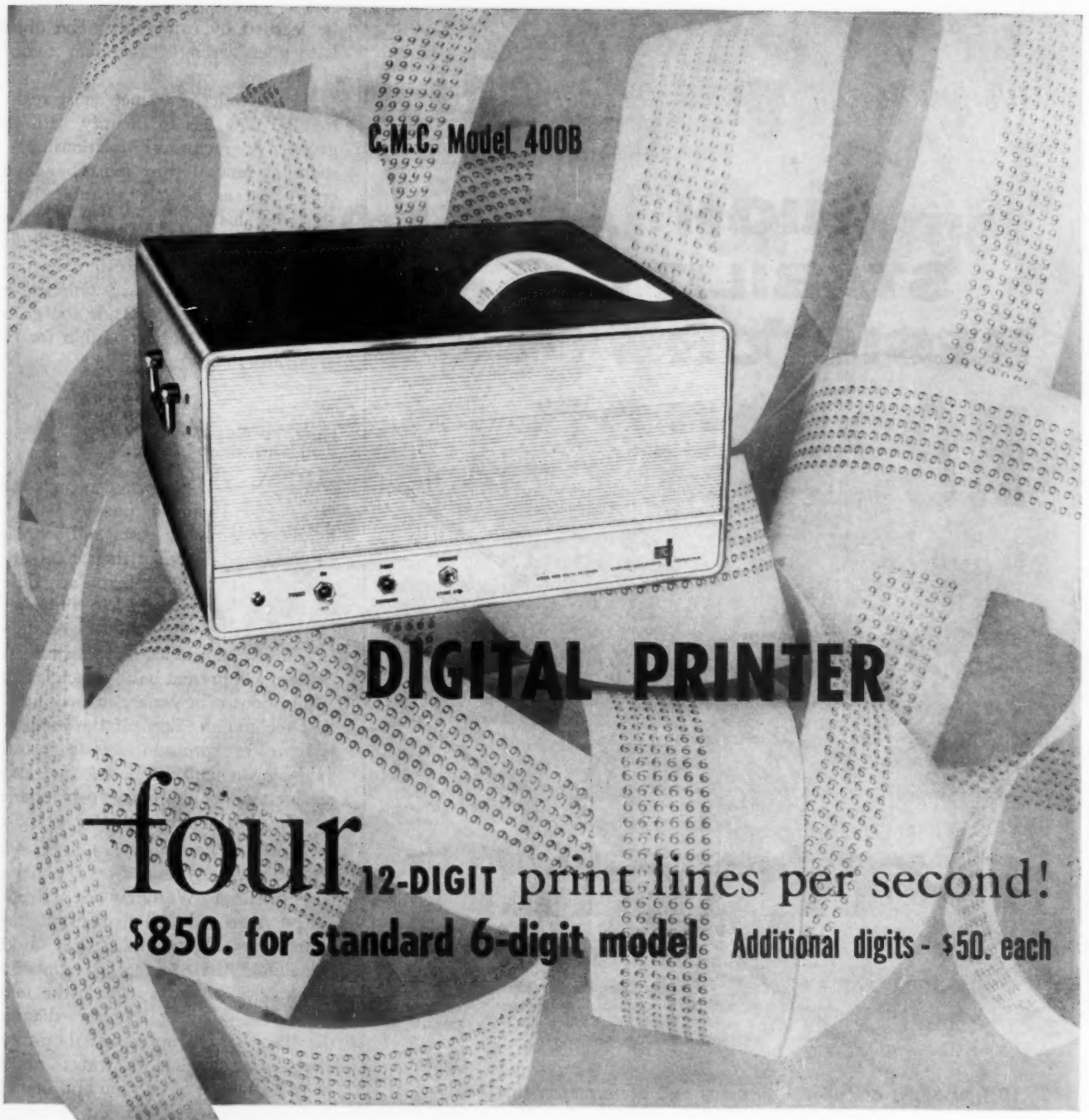
CHECK LIST FOR TRAINEES

In this particular time of confusion and reorientation Elliott presents ten points in which common patterns merge, points that the trainer should be on the look out for and correct. Here they are:

- The new supervisor tries to do everything himself. With increased responsibility the trainee worries that things are getting away from him, he is afraid to trust his (new) subordinates although not too long ago as his equals they were completely trustworthy.
- He may tend to delegate responsibility without the necessary authority to accomplish the assigned task. Although some delegation is in evidence it indicates that trainee still doesn't trust himself as a supervisor. By not delegating the necessary authority he not only places his subordinates in an untenable position, but by not indicating any confidence in them, they in turn will have no confidence in him.
- Time limits on tasks should be arrived at by discussion, not arbitrarily, and should be checked on. Nothing is gained by forcing the subordinate to attempt what he feels is an impossible task and then berating him for not accomplishing it. Immediate commendation or cirticism is far more effective than waiting until some more formal occasion.
- The trainee may take an engineer to task in the presence of other members of the group. This is better done in private where both parties can blow off steam if necessary.
- Using tact is of the utmost importance in working with engineers who formerly reported to the new supervisor. Relationships are in the process of changing and there is bound to be some resentment on the part of some of the people, even if at the subconscious level. The attitude of "you know me, Joe, everything is just the same as it's ever been," just isn't so and the trainee should be aware of the barriers that the engineers are erecting.
- Conversely, almost every new supervisor starts off with the feeling that he will still be one of the boys and that his group is different. This is not so and he should be warned to expect otherwise. Although this difference may be subtle, it does exist and must exist if he is to retain control of the engineering group.
- Budding engineering supervisors have a tendency to interfere with an engineer's work to get on with the job. In the beginning he may be able to do it faster and better but such action does not promote harmony in the group nor does it promote the development of the group as an engineering organization. As time goes on and the trainee gets away from the detailed technical aspects of his job, he becomes less qualified to personally accelerate the work. One cannot interchange experience in engineering direction and administration with experience in engineering design. The fork in the road was reached way back when the engineer agreed that supervision was what he wanted. No one can travel both roads successfully, simultaneously.



- The converse of interference is laxity. The supervisor must continually check the progress of his engineers if he is to maintain control. He should never assume that a job will be done; he should verify it for himself and verify it completely. He should make the rounds—of the lab areas, the model shop or the factory and see for himself. An important point: these visits should be regular and on no prescribed day or hour.
- Day to day operation is bounded by the limits expressed in points 7 and 8 and require constant adjustment. The art of sensing that something is slipping and letting it slip just enough so that when you step in and change assignments, the engineers affected realize you are justified in doing so; and yet, things have not slipped enough to jeopardize the project—that art can only


C.M.C. Model 400B
DIGITAL PRINTER
four 12-DIGIT print lines per second!
$850. for standard 6-digit model
Additional digits - $50. each

Operates with most existing counting equipment

WITHOUT MODIFICATION! A reliable, accurate, compact instrument that fills an industry need for a truly high-speed, low cost digital printer. It may be connected directly to digital counting instruments and will print, on standard adding machine tape, the count measured during each counting sequence. Important features include: Parallel Entry, No Stepping Switches, Relays or Moving Contacts.

Furnished standard with 6 digit print-out but up to 12 digits is optional. *Write today for complete specifications*

CMC *Subsidiary of Hancock Manufacturing Company*

Computer-Measurements Corp.

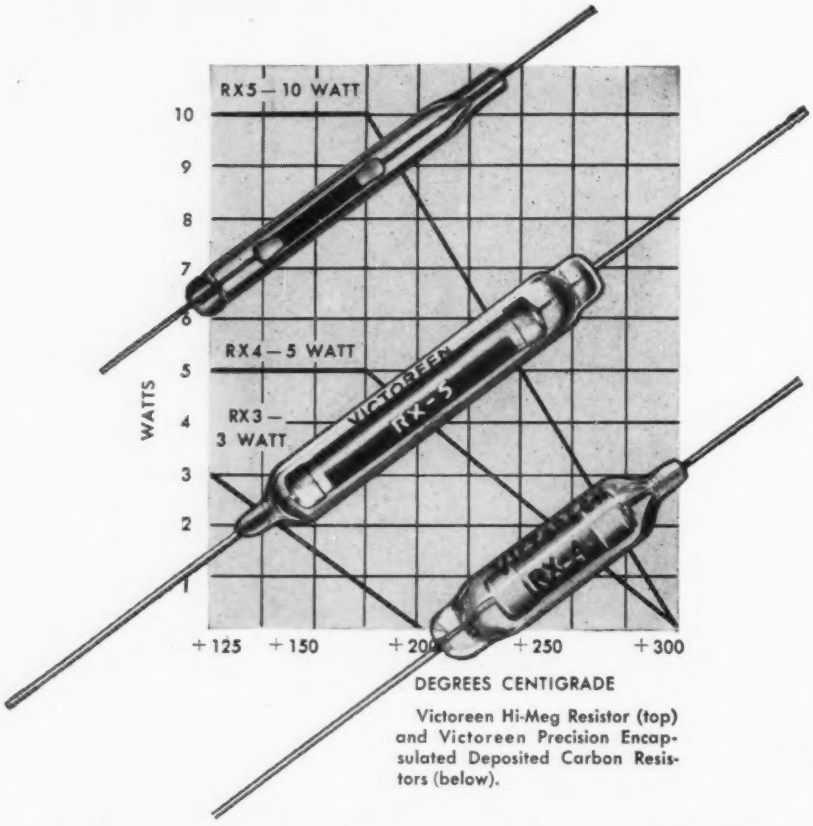
5528 Vineland Ave., No. Hollywood, Calif. Dept. 85J

CC-62

FOR MORE INFORMATION CIRCLE 84 ON INQUIRY CARD

It's just part of the Victoreen story . . .

HIGH STABILITY RESISTORS



Victoreen Hi-Meg Resistor (top) and Victoreen Precision Encapsulated Deposited Carbon Resistors (below).

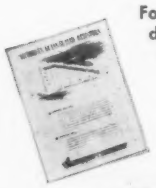
High stability, exceptional accuracy and performance that easily exceeds the normal electrical specifications of MIL 10509C—even in high ambients to 300°C where more than normal life expectancy is required. That's the story, in brief, of Victoreen deposited carbon resistors.

Hi-Meg resistors have a carbon-coated glass rod element, the ends of which are banded with silver for best electrical contact.

Hi-Meg resistors are vacuum-sealed in a glass envelope treated with special silicone varnish to keep envelope moisture-free.

For the ultimate in accuracy, stability and long-time performance, *specify Victoreen precision resistors.*

AA-5423



For the full story on Victoreen deposited carbon or Hi-Meg resistors, write for your free copy of Form 3025A.

The Victoreen Instrument Company
Components Division
5806 Hough Avenue, Cleveland 3, Ohio
FOR MORE INFORMATION CIRCLE 85 ON INQUIRY CARD

be learned by experience. The object is to guess wrong a minimum number of times.

● In general the trainee must realize that he now has to identify with the group. A reciprocal relationship, a sense of mutual trust must be developed. Just as he must learn to trust ability of his engineers, so must they learn to trust him. He is the buffer between them and the external world. Within the group he may criticize, he may reprimand. But outside the group he is the only one responsible for the group's actions.

How To Cut Costs And Influence Output

Hundreds of engineers, designers and other key technical people will be taught how to cut costs and increase engineering output for their companies at new one-day seminars scheduled during the Fall in major cities throughout the country. The seminars, arranged by Industrial Education Institute of Boston, will present basic principles and applications of a variety of new industrial techniques. Each of the methods, systems or procedures has proven valuable in cutting costs, increasing production or improving performance in many leading companies.

Advanced Techniques In Functional Drafting will be taught by a panel of experts from Westinghouse Electric Corporation and will demonstrate advanced procedures applied and taught throughout the company's engineering operations. Programs include the techniques of making lineless diagram drawings, preparing original printed circuits, producing drawings photographically and other time and money-saving methods and systems. A feature of these meetings will be demonstrations of how computers can be used to prepare completed drawings.

Don Fuller, Senior Planning Engineer of the H. K. Ferguson Company, will present a number of *Simplified Drafting Practices* that include the best features of the techniques developed by General Electric, International Harvester, American Machine & Foundry and other pioneers in simplified drafting.

Creative Engineering. will be presented by J. H. Pinard, Head of Boston University's Psychology Department and J. W. Hill, Director of Creative Development for Hercules Powder Company. The goal of these seminars

To Keep The Starfighter's Radar Fire-Control "On Target"

RCA and LOCKHEED choose

ROBINSON

all-metal MET·L·FLEX mountings

Model 1660

Farther than man can see, faster than man can think, the Starfighter's Radar Fire-Control detects and tracks the fast moving and elusive target.

This more than human RCA detecting device, in the ship's nose, is 150 pounds of high performance and reliable electronic equipment. This equipment is completely supported in a minimum of space by the twin mountings which together *weigh less than 5 pounds.*

Robinson engineered these mountings to provide maximum protection against take-off shocks, abrupt change of path, 4G sustained acceleration and temperature extremes.

Met-L-Flex fabricated wire cushions feature inherent damping and require no auxiliary friction devices. These mounting assemblies provide quick release attachment to the airframe.

The twin mountings shown are simple, light weight, rugged and possess **INHERENT DAMPING.**

There are **TWENTY-SIX** other vital electronic devices protected by Robinson engineered mounting systems throughout the Lockheed F-104 Starfighter — including the pilot's instrument panel.

VIBRATION CONTROL IS RELIABILITY CONTROL

ROBINSON AVIATION · INC · TETERBORO · N·J·

WEST COAST ENGINEERING OFFICE • SANTA MONICA • CALIFORNIA

FOR MORE INFORMATION CIRCLE 43 ON INQUIRY CARD

NEW Precision in a Small Package

DETROIT

Class 4

TyniSwitch

...if your Precision Snap Switch must have: Small Size 7/16" x 17/32" x 1-3/16" • High Electrical Rating • Choice of Operating Forces—3 ozs. to 12 ozs. on the pin • Compactness for ganging • Wide choice of terminals—solder, screw, standard spade, and junior tab.

Here's the switch to do the job

Precision performance and outstanding contact life are features of the new TyniSwitch. Force and movement are held to very close tolerances. The patented blade design produces a fast and positive snap-action that is virtually "bounceless," and dependable performance under conditions of shock and vibration. For full information write for Bulletin 270.

U. L. listed 15 Amp. 125-250 V., ½ hp. 125-250 V. AC.

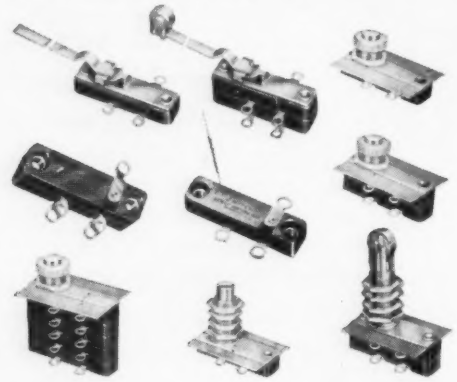
Class 2 TyniSwitch

A specialized switch for applications requiring No. 8 screw terminals. Mounting bases are either left hand or right hand.

For full information write for Bulletin 263-B

Class 1 TyniSwitch

The Class 1 TyniSwitch is unusually small for a full 15 ampere rated switch. It also is a versatile design, lending itself to special adaptation.



Quality Protects Your Investment--

AMERICAN-Standard Quality Is Available At No Extra Cost.

Stratford, Connecticut

DETROIT CONTROLS

Division of AMERICAN-Standard

FOR MORE INFORMATION CIRCLE 86 ON INQUIRY CARD

MANAGEMENT

is to present the experienced engineer with a usable formula for more effective problem solving by teaching him how to free his mind of restricting inhibitions.

INDUSTRIAL EDUCATION INSTITUTE SEMINARS

SEMINAR TOPIC	DATE	CITY
Simplified Drafting Practices	Sept. 18	Chicago
Advanced Techniques in Functional Drafting	Sept. 24	Cleveland
Clear Technical Writing	Oct. 1	Chicago
Advanced Techniques in Functional Drafting	Oct. 2	New York
Clear Technical Writing	Oct. 8	Cleveland
Clear Technical Writing	Oct. 9	New York
Simplified Drafting Practices	Oct. 15	Detroit
Creative Engineering	Oct. 16	Chicago
Effective Speaking for Engineers	Oct. 16	Boston
Basic Approach to Work Simplification	Oct. 17	Chicago
Simplified Drafting Practices	Oct. 23	Philadelphia
Clear Technical Writing	Nov. 5	Boston
Simplified Drafting Practices	Nov. 6	Philadelphia
Clear Technical Writing	Nov. 7	Pittsburgh
Planning for Research and Development	Nov. 7	Boston
Advanced Techniques in Functional Drafting	Nov. 13	Chicago
Simplified Drafting Practices	Nov. 14	Detroit
Creative Engineering	Nov. 19	New York
Basic Approach to Work Simplification	Nov. 20	Cleveland
Creative Engineering	Nov. 21	Cleveland

To help technical men prepare better reports, procedures, manuals and other written material, Robert Gunning, will present his formula for *Clear Technical Writing*. Tailored especially for one-day presentation, the Seminar aims to teach engineers, designers and others who write on technical subjects how to get their thoughts on paper faster, more easily and more understandably.

Several of the Seminars will be devoted to *A Basic Approach to Job Improvement and Work Simplifications*. Designed for application by companies of any size, and in every phase of op-

eration, this course is directed at the technical management level. Work Simplification authorities will present a workable formula for reducing costs by eliminating unnecessary work, combining and re-arranging functions, and simplifying essential operations.

Modest registration fees at each of the convenient one-day Seminars include attendance at morning and afternoon sessions, luncheons, coffee breaks, all necessary materials and supplies, and a set of Seminar notes for continuing reference.

Because the IEI limits the seminars in size, admission is by registration only. Information and reservations for any or all of the seminars are available from Industrial Education Institute, 25 Huntington Avenue, Boston 16, Mass. Or circle 166 for additional information and registration forms.

ENGINEER EVALUATION

Haloes vs Correlations

Time-hallowed haloes surrounding such factors as class standing, participation in extra-curricula activities and graduation from a particular college were shattered by correlations presented by Robert A. Martin and James Pachares at WESCON. These men undertook the application of statistical techniques in the development of equations that would give a fair and consistent evaluation of employment applications at Hughes Research and Development Laboratories.

Martin and Pachares tabulated all variables normally considered important in selecting engineers for employment, factors which can be obtained from an examination of employment questionnaires, transcripts of college grades, interview reports and references. They labeled these variables "predictors". Of the 27 predictors included, only eight were determined to be statistically significant:

Level of academic degree
Number of professional publications

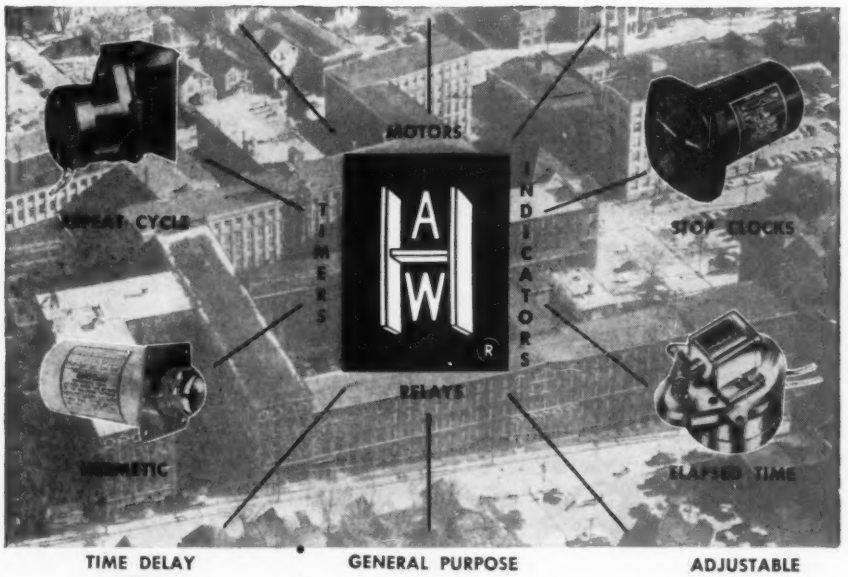
one source for all timers!

• *the*
• **A. W. HAYDON COMPANY**
• *offers a* ***COMPLETE LINE*** *of...*
• **STANDARD and CUSTOM DESIGNED**
• **TIMING MOTORS and DEVICES!**
• for military and industrial applications. Illustrated are some of these units . . . any can be modified to meet your specific requirements if the basic design is not adequate.

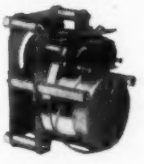
DIRECT CURRENT

400 CYCLE

GOVERNED



TIME DELAY



GENERAL PURPOSE

ADJUSTABLE

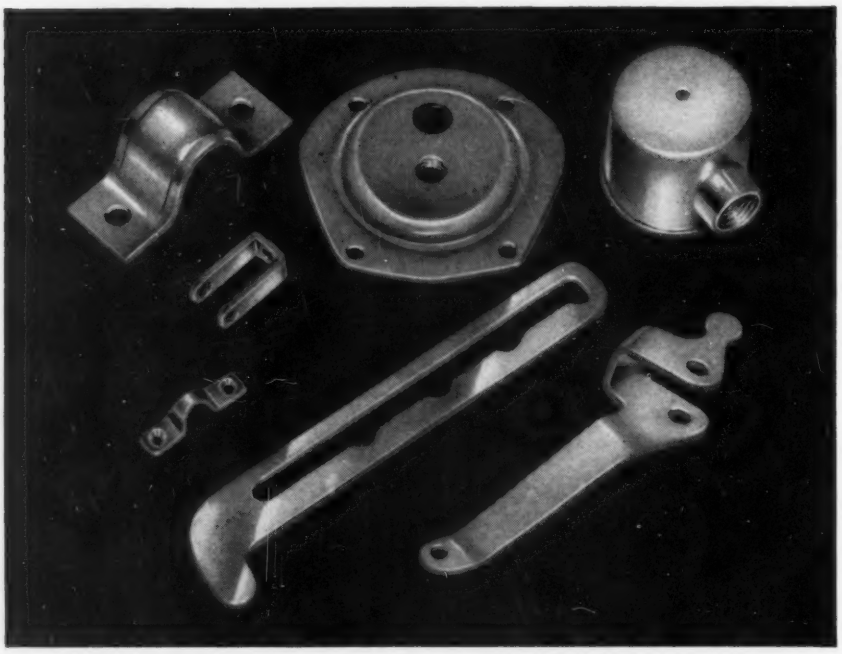
Shown below is the new catalog of The A. W. Haydon Company describing all of the basic types of units available and many of the "specials". Included in this 25-page catalog are 60 photographs of timers, 30 dimensional drawings, and 50 charts and diagrams. This complete catalog will be supplied on request.

Long a pioneer in the timing field, The A. W. Haydon Company is prepared to assist you in solving your timing and control problems. When a solution to your problem has been reached, The A. W. Haydon Company is prepared to follow through with production geared to meet your requirements whether a basic timing unit or a highly specialized device is required.

See us at the National Electronics Conference, Chicago, Oct. 7-9, Booths 135-136.

The A. W. HAYDON Company
239 NORTH ELM STREET, WATERBURY 20, CONNECTICUT
Design and Manufacture of Electro-Mechanical Timing Devices
FOR MORE INFORMATION CIRCLE 87 ON INQUIRY CARD

If you use forged or cast parts like any of these...



we can cut your costs by STAMPING THEM!

By stamping parts like these which formerly had been forged or cast, we have made substantial savings for our customers!

Such savings have resulted from reducing cost of original parts as well as in machining and finishing operations.

The reason we can do this when many others can't is *know-how* acquired during 42 years' experience, plus unexcelled organization and equipment.

With an efficient nation-wide sales force, we will quickly show you how many forged or cast parts may be stamped, and the AQL improved!

Also yours for the asking . . .
Our Stampings Brochure!

DE-STA-CO

DETROIT STAMPING COMPANY

Established 1915

406 MIDLAND AVE., DETROIT 3, MICHIGAN

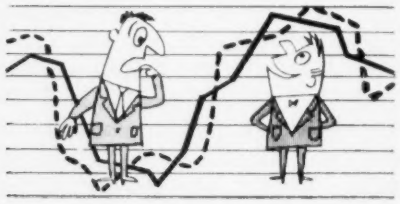
"America's Leading Job Stamping Manufacturer"

Look to Detroit!

FOR MORE INFORMATION CIRCLE 88 ON INQUIRY CARD

MANAGEMENT

- Number of honor societies to which elected
- Major in Physics
- Major in other than Mechanical Engineering, Electrical Engineering or Physics
- Major in Electrical Engineering
- Number of patents
- Number of Fellowships



The equation based on the above factors accounted for 50% of the variance among ratings and was within 6% of actual ratings for 75% of the cases tested. No significant correlations were obtained in a separate correlation analysis relating personality characteristics of Experimental Ability, Analytical Ability, Initiative, Industry, Originality, General Knowledge, Sincerity, Appearance, and Leadership with rate of salary growth.

No significant correlations were obtained between undergraduate class standings and salaries of engineers and between college ratings and salaries.

Factors such as age, quality of reference checks, rating of school from which graduated and other factors normally considered important during employment consideration did not appear to be significant in determining entrance rating. Class standings also did not appear to have any correlation to salaries. Other results of interest:

► For engineers with four years' experience, there was barely significant positive correlation between class standing and salaries.

► For the engineers with six and eight years' experience, there was no correlation whatsoever.

► For engineers as a group, there were no correlations whatsoever between class standings and salaries.

► Grades obtained in college did not appear very important in evaluating an applicant's theoretical knowledge or ability.

PROFESSORS: HEAR! HEAR!

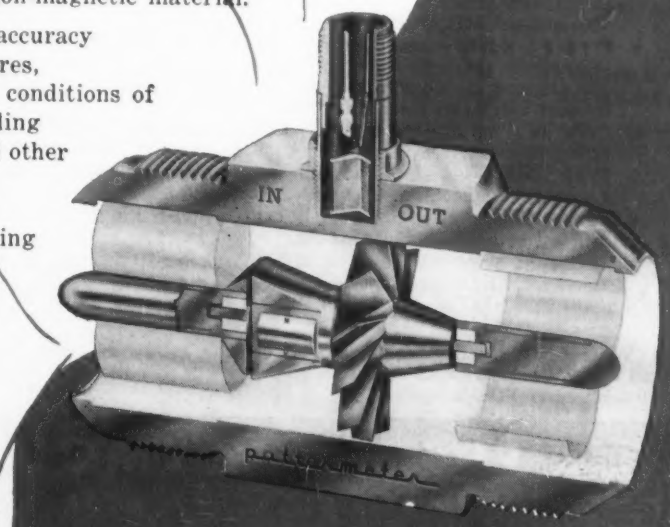
Before the above results were obtained Martin and Pachares attempted to de

Perfect performance by POTTERMETER

POTTER Flow Control Systems are currently operating at temperatures as low as —455°F. and as high as 1000°F., at pressures up to 35,000 psi—with no ceiling.

The POTTERMETER Flow Sensing Element, is based on a unique venturi design with a *bearingless*, hydraulically-positioned rotor, and can be made of stainless steel or any non-magnetic material.

POTTER systems feature high accuracy over a wide range of temperatures, pressures, density and viscosity conditions of liquids and liquefied gases, including acids, caustics, hydrocarbons and other corrosives. They are shock and vibration-resistant and can be utilized with a variety of indicating totalizing, recording and/or control instrumentation.



Only POTTER makes the POTTERMETER

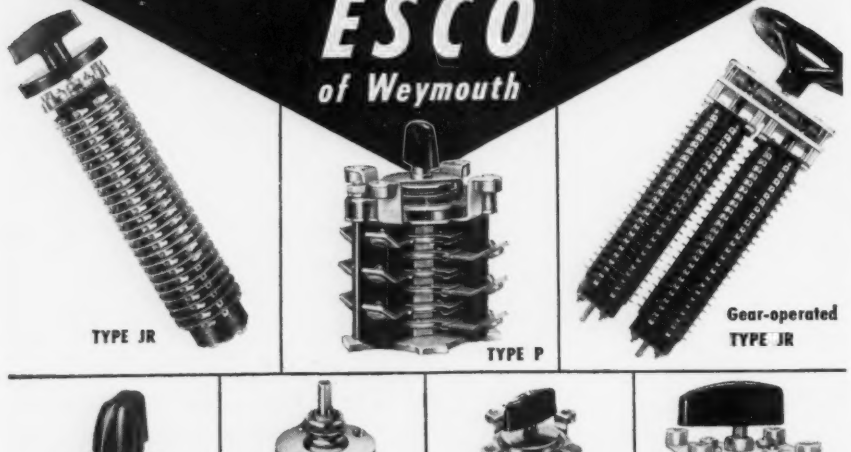
Write TODAY for Bulletin T1

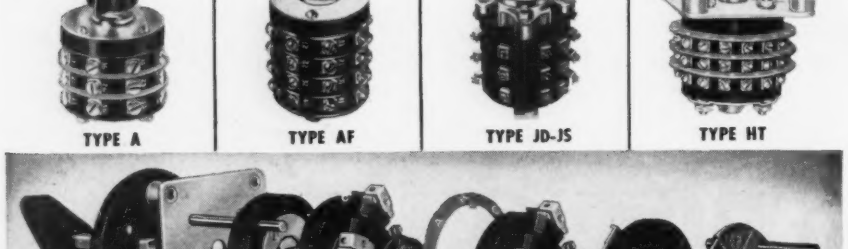
POTTER

POTTER AERONAUTICAL CORP.
U. S. Route 22, Union, New Jersey
MUrdock 6-3010

FOR MORE INFORMATION CIRCLE 89 ON INQUIRY CARD

SPECIAL SWITCHES are STANDARD with ESCO of Weymouth





When you need a SPECIAL switch . . .

ESCO standard, uniform components can be assembled to meet your requirements; or a deviation from one of our standard types will give you a special switch at a standard switch cost. *Over 90% of our production is SPECIAL in one way or another.*

These standard switches can be modified to fit your application:

- **TYPE A** — up to 8 positions, 7 sections maximum, detent-mechanism, rating 5 amperes — 125 volts a-c/30 volts d-c.
- **TYPE AF** — up to 8 positions, 6 sections maximum, detent-action, rating with resistive load 5 amperes at 28 volts d-c or 115 volts 400 cps, per MIL-S-6807.
- **TYPE P** — Multi-section, up to 4 positions, snap-action, rating 10 amperes — 125 volts a-c, 5 amperes — 125 volts d-c, 30, 60, 100, 200 amperes at 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
- **TYPE JR** — up to 8 positions, 30 sections maximum, detent-action, rating 10 amperes at 125 volts a-c, 5 amperes 125 volts d-c.
- **TYPE JD-JS** — up to 8 positions, 5 sections maximum, detent-action or snap-action, rating 30 amperes at 230 volts a-c.
- **TYPE HT** — up to 16 positions, 6 sections maximum, detent-action, rating 5 amperes at 125 volts a-c.
- Bureau of Ships No. 9000-S6202-74085 rating 10 amperes at 120 volts a-c. BuShips 9000-S6202-74090, 9000-S6202-74096, and 9000-S6202-74224, ratings 30, 60, and 200 amperes, 500 volts a-c — 250 volts d-c.

Write for data sheets or catalog on ESCO rotary multipole switches — or send us your requirements and we'll give you full specifications on the ESCO switch that meets YOUR need.

ESCO of WEYMOUTH
ELECTRO SWITCH CORPORATION
Weymouth 88, Massachusetts

FOR MORE INFORMATION CIRCLE 90 ON INQUIRY CARD

termine the relationship, if any, between university ratings and salaries; no correlation whatsoever. In desperation they then tried to determine the relationship, if any, between products of school groupings and class standings with salaries; no correlation whatsoever.

Universities cooperating with Martin and Pachares were informed of these results. Here is one interesting reply from the Registrar of California Institute of Technology:

"The type of education we offer at Cal Tech must, of necessity, consist for the most part of book assignments. The student follows a schedule. He learns by memory what the book says. He cannot disagree, because he is sure to be wrong. The book offers well-established facts—not opinions; or if opinions, they are amply justified. Then he submits to an examination, made up to test his ability to correlate the facts, to deduce new facts and obtain new relationships but always in a definite pattern. The student who best follows the pattern gets the top grade.

"We find outstanding students developing a technique of passing examinations. The best student, so far as grades go, can cover perhaps a hundred times as much material as the poc ·st. He knows just what the professor is going to ask on the examination, and makes sure to have it down cold. The poor student always studies the wrong things, usually because of special interest in them.

"Now this poor student may be doing some creative thinking. If it does not apply to the work in hand, he will be disappointed. How does a professor with a class of twenty students encourage each to go his own way and still cover what the course specifies, "Elementary Electronics"— "Surveying" — etc.? . . . "You have also heard the opinion expressed that the fellow who made good was one who received poor grades in school but excelled in athletics or some other "social" type achievement.

"One of our own studies of salaries correlation for all graduates seems to indicate that the student who had a mixed program of extra-curricular activities, for which no scholastic record is shown, and reasonable grades in his courses, climbed well above his fellows

after, say, five or more years out of college."

Taking their cue from the comments offered by Cal. Tech's Registrar, Martin and Pachares launched a more ambitious project—a detailed correlation study involving all the variables in the backgrounds of applicants as revealed by their employment questionnaires, reference checks, interview comments and transcripts of college grades. These were the variables they called predictors and this study yielded the information presented in the first several paragraphs of this report of their work.

Guidelines for Better Electromechanical Designs

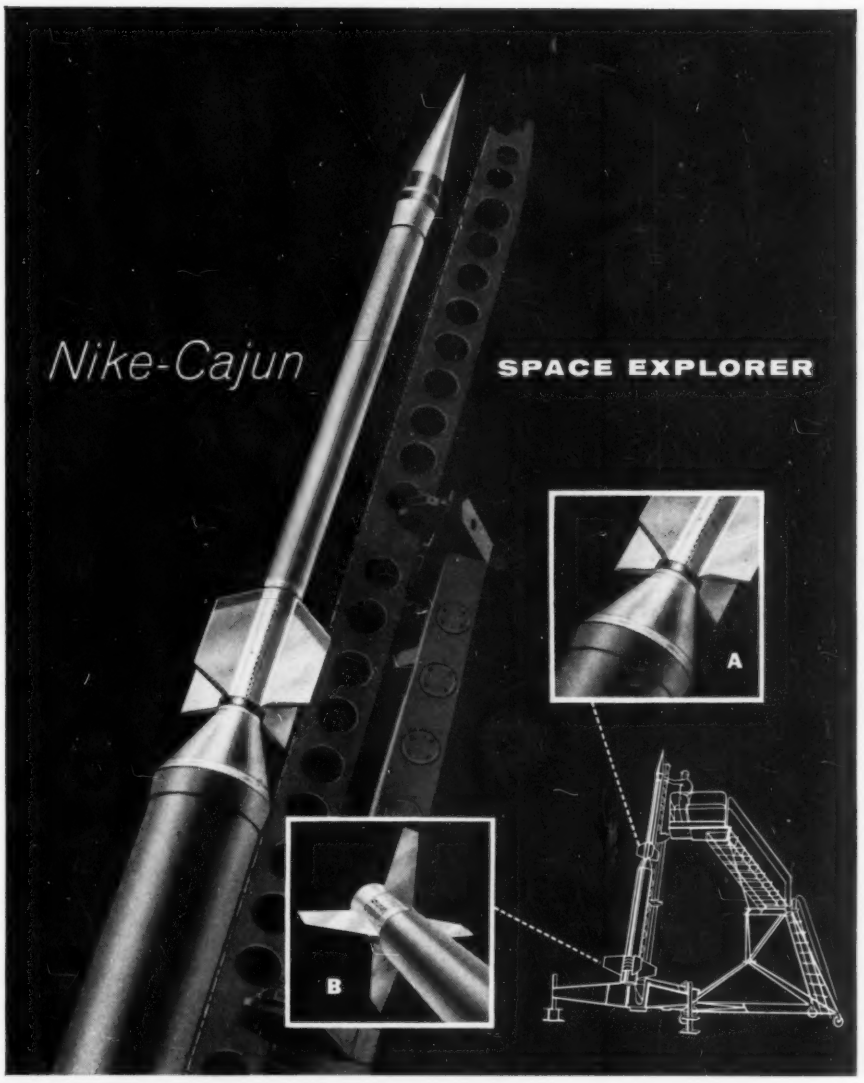
One method for management to emphasize reliability in components and systems design is to call the attention of designers to newly available sources of information in the field. The U. S. Dep't. of Commerce has just made available for industry use twelve simple guides for the design of reliable electronic equipment in a volume prepared for Navy electronic engineers. The report was compiled primarily for guidance in the design of ground-based data-gathering and data-assessing equipment, but contains information useful to designers of other types of electronic devices. Most of the data was drawn from an extensive literature survey. The report includes an 89-item bibliography.

The guides were based on studies of the effects of increased equipment complexity, distribution of causes of equipment failure, technique or reliable design, and selection of components. Such tube-reliability factors as filament current surges, cathode-interface formation, tube envelope temperatures, new cathode designs, and the use of special tubes also were considered.

The report: PB 121123 *Twelve Guides to Reliable Electronics Design*, the Office of Technical Services, U. S. Department of Commerce, Washington 25. It contains 57 pages, price $1.50.

Next month ELECTROMECHANICAL components & systems DESIGN will publish an article by Seymour Nozick that enables designers to predict or measure the reliability of most electronic and electromechanical designs with the use of three simple charts.

Mr. Nozick is a specialist in operations analysis and reliability studies applied to aircraft weapon systems.



How Magline Magnesium Helps University of Michigan Probe Mysteries of Upper Atmosphere

Time: *International Geophysical Year*
Launching Site: *Fort Churchill, Canada*
Objective: *Upper air research . . . 100 miles above the earth*

Magnesium is playing an important role in the success of the Nike-Cajun sounding rocket. Cost-saving design components, made by Magline have eliminated earth-binding pounds from the rocket . . . while meeting the rigid demands of supersonic speeds!

Magline magnesium improves down-to-earth products too. In automobiles, office machines, industrial equipment, consumer durables—wherever weight and cost are important, design engineers are finding a practical solution with magnesium. World's lightest structural metal, magnesium can be cast, formed, extruded, drawn or worked into virtually any size or shape! Tooling costs are lower . . . machining, fabrication, processing, handling, assembly costs too! Put Magline experience to work for you. Four plants to serve you . . . with complete facilities for cast or fabricated products. Design and technical service available.

MAGNESIUM COMPONENTS OF NIKE-CAJUN ROCKET:

A Coupling is a cone-shaped magnesium sand casting which keeps the two stages of the rocket integral until differential drag separates them.

B Each Nike fin assembly consists of a four-piece quadrant and fin. Quadrants are magnesium sand castings. Fin is a weldment of magnesium structural plate and magnesium sand castings.

Please send me my copy of Data Bulletin M-50 on Magliner Magnesium
Check interest:
☐ Die Castings ☐ Sand Castings
☐ Permanent Mold ☐ Fabrications
Name_____
Address_____
City_____ Zone____ State_____

MAGLINE INC., P. O. BOX 439, PINCONNING, MICHIGAN
Canadian Factory: Magline of Canada, Ltd., Renfrew, Ontario
FOR MORE INFORMATION CIRCLE 91 ON INQUIRY CARD

39 MAJOR COMPANIES SLASH PRODUCTION COSTS WITH A LIQUID LOCK FOR THREADED FASTENERS

LOCTITE® SEALANT

One drop of Loctite replaces lock nuts, lock washers and other mechanical locking devices

This new liquid plastic sets up tighter than mechanical locking devices to prevent fasteners from loosening under vibration. Use Loctite on nuts, machine screws, set screws, studs, adjustment screws.

Fasteners can be Loctite-treated before application by tumbling . . . individually treated by hand . . . automatically treated right on the line.

Loctite gives your product highest resistance to shock and vibration . . . up to five times removal torque of other devices. Various grades permit reduction of locking torque where desired.

Loctite costs but a fraction of mechanical locking devices . . . helps you slash production costs!

FREE LOCTITE TR #5

12-page engineering report complete with charts, graphs, properties, application tips. Here's all you need to take advantage of Loctite's tremendous cost-saving advantages.

LOCTITE® SEALANT

AMERICAN SEALANTS CO. • 109 Woodbine St., Hartford 6, Conn.

CIRCLE 92 ON READER INQUIRY CARD

STAFF COLUMNIST

Renato Contini

Renato Contini is Research Coordinator at New York University's College of Engineering.

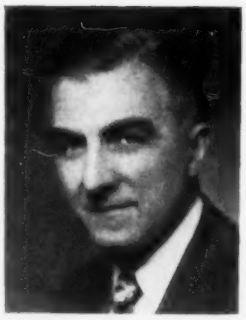
HUMAN FACTORS IN DESIGN

Only within the past few years has a large segment of the engineering profession become significantly aware of man as the operator of tools and equipments, as a link in an operational chain or system or as a participant in an operational environment. This increasing awareness (on the part of the engineer) is evidenced by the increased number of articles on "human factors" appearing in engineering literature. Expressions such as work science, ergonomics, human engineering, bio-technology, bio-mechanics are becoming more and more familiar terms.

I do not mean to imply that the design engineer intentionally neglected the human factor when equipment was being designed for which man was the operator or when an environment was being developed in which man was to operate; rather, that until quite recently, even into the early phases of World War II, much of such designing was done on an intuitive or at best on an empirical basis.

Some engineers, particularly those in management or in industrial engineering positions, were aware of certain aspects of the situation, the need for some greater concern for the man part of the man-machine complex. The fact that techniques such as time and motin studies were being employed in the planning of production processes showed there was recognition that man's capacities to perform and adapt could be enhanced or diminished. But even at this level there were no radically new departures since the times of Taylor and Gilbreth.

On the other hand, within a number of other disciplines (psychology and physiology as prime examples) there was more concern for and greater curiosity about man, to learn how he responded to internal and external stimuli, how he withstood emotional, physical and environmental stress, how such were evidenced, and how they could be measured. In Europe particu-



larly, perhaps because of economic necessity, perhaps because of a greater curiosity in this problem area, scientists such as Atzler in Germany, Bernstein in Russia and Drillis in Latvia, were doing research leading to a new area of specialization — then called World Science.

World War II with its advanced technology made possible the development of implements of war which taxed or exceeded the capacities of the men who were to operate and control them. Aircraft could fly higher, submarines could remain submerged longer, battles were fought in tanks in tropical climates and men were isolated in arctic regions. Men were being exposed to environmental stresses of an order never before experienced.

Psychologists and physiologists and the other life scientists were recruited to develop the basic knowledge about how man performs under a variety of conditions. From this basic information, an area of specialization has been emerging, so that now you have as an engineer and designer more formalized data from which to draw. Although recognized under a variety of names, the consensus now seems to favor the term Human Factors for this area.

The purpose of this column is to keep you up to date with progress in this area, to invite from those who are more experienced, advice and information to be passed on to those interested, to review, or have reviewed and abstracted, articles of outstanding interest and perhaps dare to suggest new avenues for research. Occasionally, men who have been long associated in the field of human factors will be invited to serve as guest columnists.

In such a comparatively new specialty much material may be controversial. I hope that controversies, should they arise, can be exploited fruitfully—and that as a result of all the effort, a better understanding of man may be obtained.

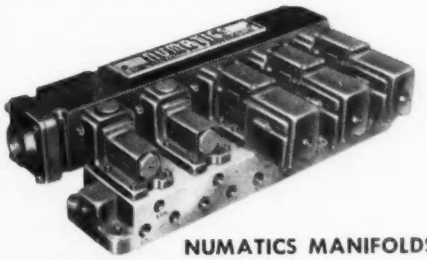
Specify NUMATICS VALVES

... there are no "equivalents"

SAFETY...

surpassing any other air valve on the market

In a momentary contact valve application, safety . . . for operator and machine alike . . . depends on a valve that will not shift when de-energized. Numatics DSA4 valves *can't* shift. Numatics exclusive detent does the trick . . . it safely, positively locks the valve spool in position the split second the valve is de-energized. What's more, this locking action is independent of air pressure, friction or packing drag. Numatics momentary contact air valves are, *in fact,* safer, more dependable than any other valves currently on the market. Write for complete information today.



NUMATICS MANIFOLDS

Numatics individual exhaust and conduit manifolds provide perfect "running mates" for Numatics solenoid actuated valves.

4-WAY HAND VALVES

For the utmost reliability and versatility, look first to Numatics 4-way hand valves. 136 models in 4 pipe sizes, a valve for every application.

NUMATICS, Inc. MILFORD, MICHIGAN

CIRCLE 93 ON READER INQUIRY CARD

to THIS

STONITE CUSTOM-MADE COILS COVER THE WIDEST SIZE RANGE —FROM THE TENTH OF A POUND TO A TON!

Here are two examples of this cycle, illustrating Stonite's versatility and manufacturing know-how.

Proven high-quality manufacturing materials, outstanding service facilities and prompt deliveries are of equal importance in Stonite's picture. For coils, mite to man size, you can depend on Stonite.

Write today, describing your requirement or request that a sales engineer call.

PAPER SECTIONS • FORM WOUND
LAYER WOUND • BOBBIN WOUND
PRECISION WINDING
HIGH TEMPERATURE COILS
COPPER AND ALUMINUM CONDUCTORS

Stonite COIL CORP.
Route #25, Yardville New Jersey
JUniper 7-7323

CIRCLE 94 ON INQUIRY CARD

STAFF COLUMNIST

Emile Labin

Emile Labin is President of Automation-Electronique-Recherche Opérationelle in Paris, France.

Report from France

The United States is producing not far from half of the entire world's industrial output. In electronics the American contribution is even larger than in any other field. Yet America is not doing half of the research and development work going on in electronics by a long shot. European research efforts remain important both in quality and quantity, even though main trends of the industry throughout the world are bound to be determined by the American giant.

These reports from France are written with the conviction that while in general we have a lot to learn from the United States, we have something to contribute on many specific items. Thus, conforming to traditional French logic, I shall devote my first report to a general survey on the present state of our industry.

STATISTICS

French statistics usually divide electronic activities into four groups:

- "Consumer products" including radio and TV receivers, electro-acoustics such as pick-ups and public-address systems
- "Professional products" including all non-consumer goods such as military and civilian communication systems, radar, navigation, radio and TV broadcasting, industrial electronics, etc.
- Components
- Tubes including vacuum tubes and semi-conductor devices.

Cables, telephone subsets, switching systems, mechanical computers and similar components and systems are not considered as part of electronics.

Production in 1956 is shown on Table I. In this table and all following tables, French currency has been converted into American dollars. All sales figures include all taxes at the rate of 25 cents for 100 Francs.

Table II shows the quantities of main consumer products sold in 1956, the total number in service at the end of 1956, and the rate of increase.

TABLE I Total Sales in 1956

Consumer products	125,000,000	35%
Professional products	125,000,000	35%
Components	70,000,000	20%
Tubes	35,000,000	10%
Total	$355,000,000	100%

TABLE II Quantities of Receivers

	Sold in 1956	In Service December 31, 1956	Rate of Increase 1956
Radio Receivers	1,000,000	10,000,000	10%
TV Receivers	260,000	500,000	52%

The rate of increase of TV receivers proves that France is still in the early stages of TV development. There are now 17 transmitters in France covering 50 percent of the total population. Within the actual coverage only 6.5 percent of homes are equipped with TV receivers. Consumer products are traditionally slow to gain momentum in the French market even compared to other European markets, and TV follows the usual pattern. This lag in TV production may be due to the fact that the French public is rather conservative or simply that they enjoy better entertainment facilities.

Division of the market of professional products among types of customers is indicated in Table III.

TABLE III Customers for Professional Products

Military	75%
Civilian Government	15%
Private Industry	6%
Miscellaneous	11%

The government represents 90 percent of the business in the "Professional" group. This should not be surprising considering that in France, as in

most of Europe, all communication facilities and almost all broadcasting facilities are owned and operated by the government.

PERSONNEL AND SALARY

Personnel is divided within the industry as shown in Table IV. The division between "staff" and "workers" corresponds to the American division between "monthly" and "hourly" paid. The last column indicates output per man obtained by dividing the numbers of the first column of Table I by the total of the third column.

TABLE IV Employment in 1956

	Staff	Workers	Total	Output/ Man in Dollars
Consumer products	3,300	10,000	13,300	9,400
Professional products	10,000	10,000	20,000	6,250
Components	2,000	8,500	10,500	7,000
Tubes	2,400	5,000	7,400	4,500
Total	17,700	33,500	51,200	7,000

Total employment represents an increase of 15 percent over the year 1955.

Salaries paid in 1956 are shown in Table V. For each classification the first column indicates the total salaries paid by the industry division in 1956 and the second the average individual yearly salaries.

It is important to remember that in France one should add to the direct salaries an amount approximately equal to 45 percent for staff and 65 percent for workers. This sum is paid indirectly for various social securities such as health insurance and other fringe benefits. The average over-all yearly earning amounts to $2,500 for an output per man of $7,000.

The rate of growth of the electronics industry in France is quite impressive. Total yearly sales of the industry in millions of dollars increased from about 60 for 1948 to about 350 for 1956. This rate will undoubtedly continue. TV is only beginning and communications and industrial electronics are far from the saturation level.

WHO DOES THE BUSINESS?

French electronics has been a small-business industry. In the last years however a certain amount of concentration has taken place:

- 45 companies with 32,000 people do 68 percent of the business
- 90 companies with 9,000 people do 16 percent of the business
- The remaining 16 percent is divided between a large number of small companies totaling 10,000 people.

Concentration of activities is greater in the professional group taken alone:

- 20 companies with 18,000 people do 92 percent of the business
- 15 companies with 1,500 people do 6 percent of the business
- 65 companies with 500 people do 2 percent of the business.

This data and that contained in all the tables have been obtained through the courtesy of the Economic Data Section of the "SNIR" (National Syndicate of Radio Industries).

French electronic industry is privately owned but government is the main customer for the professional group. The Government runs some research organizations, civilian as well as military, but does not own any manufacturing facilities.

R&D FOR EXPORT

Tradition in France, as in other European countries, emphasizes research and development in engineering. This emphasis is a heavy load on the French electronics industry. Whereas an investment of 3 to 3.5 percent of the industry's sales on R & D might be considered sufficient or even daring in the United States, an investment of 15 percent of sales is considered a necessity in France. In fact, the French industry is becoming convinced that even a greater R & D effort will be required if the industry is to progress in spite of its limited market. As a result, export possibilities to the United States from France are much better in R & D than in industrial products.

TABLE V—DIRECT SALARIES AND WAGES PAID IN 1956

	STAFF		WORKERS		OVER ALL	
	Total Dollars	*Average Dollars*	*Total Dollars*	*Average Dollars*	*Total Dollars*	*Average Dollars*
Consumer products	8,000,000	2,500	100,000	1,000	18,000,000	1,350
Professional products	26,500,000	2,650	12,500	1,250	39,000,000	1,950
Components	5,000,000	2,500	8,500	1,000	13,500,000	1,250
Tubes	8,000,000	3,300	5,000	1,000	13,000,000	1,750
Total	47,500,000	2,800	33,500	1,060	83,500,000	1,630

—IF IT'S PRINTED CIRCUITS, WE CAN HANDLE THEM!

Printed Electronic Corporation can produce high quality circuits in small quantity runs or large volume production. We are fully equipped to design and prepare your circuits for production and to manufacture them by the most economical method consistent with quality, quantity and other specifications.

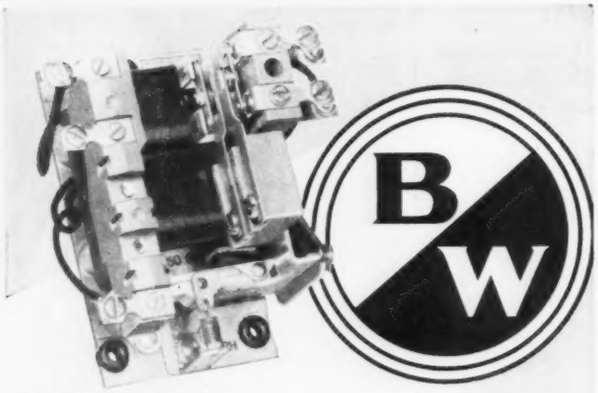
PEC's patented Narcus process for plating holes provides greater reliability and economy on printed circuit designs. This test-proven process, in which copper is plated on plastic, features excellent conductivity . . . more uniform thickness of hole wall . . . and greater bond strength to plastic.

If prototypes present a problem, you will find it worth-while to investigate the Protomaka Machine. Protomaka is a complete portable laboratory that can produce etched and plated circuits by a photographic process in only forty minutes.

For high quality printed circuits in prototypes or production consult . . .

Printed Electronics corp
7 North Ave. Natick, Mass.

CIRCLE 95 ON INQUIRY CARD



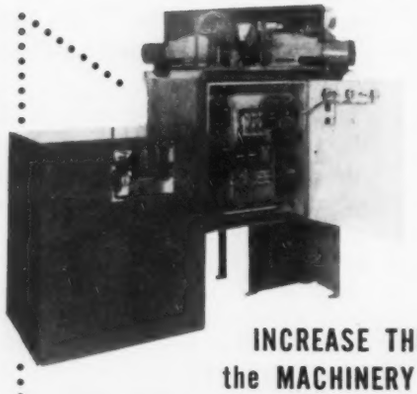
Floatless
LIQUID LEVEL
and **INDUSTRIAL CONTROLS**

● Write for latest catalog covering the complete line of B/W Induction Relays, Relay Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

Controls will never trouble you, when you buy B/W

B/W CONTROLLER CORPORATION
2152 East Maple Avenue, Birmingham, Michigan

CIRCLE 96 ON INQUIRY CARD



INCREASE THE VALUE of the MACHINERY YOU MAKE

GIVE them the CONTROLS to run themselves

Progress of Automation requires that you provide controls for the equipment you make. But perhaps designing control systems is not your specialty. Because the application of control systems to machines for automatic operation is a specialty with us, we believe we can supply you with packaged controls for your machinery, faster and more economically. Call or write for a control application analysis.

JOHN C. WHIDDETT CO.
Specializing in Industrial Control Problems
3850 GARRETT ROAD • DREXEL HILL, PA. | CLearbrook 9-3636

CIRCLE 97 ON INQUIRY CARD

The Engineering Shortage: Statistics versus Opinion

Over the past few years, a few editorials and small incredulous voices have questioned the shortage of engineers in this country. Now they have some statistics to back up their personal opinions and experiences.

In a publication recently released by the National Bureau of Economic Research, Drs. David M. Blank and George J. Stigler offer statistical evidence that there is no shortage of engineers in the U. S. The authors began their study with a comparison of engineering salaries with earnings in selected fields since 1929, the earliest year for which reliable data were available.

They found that ratios of engineering salaries to earnings of three groups of independent professional practitioners—doctors, dentists and lawyers—rose during the 'thirties but declined sharply after 1939. By 1951 the salary income ratio for engineers compared with physicians was forty per-cent below its level in 1929; for engineers and dentists, sixteen per-cent below; for engineers and lawyers, three per-cent below. The decline was substantially greater when measured against a 1939 base.

Salaries of engineers and full-time average earnings of manufacturing wage and salaried employees and all wage and salaried employees fluctuated in about the same manner between 1929 and 1939. After 1939 wage earners increased their earnings more sharply than engineers.

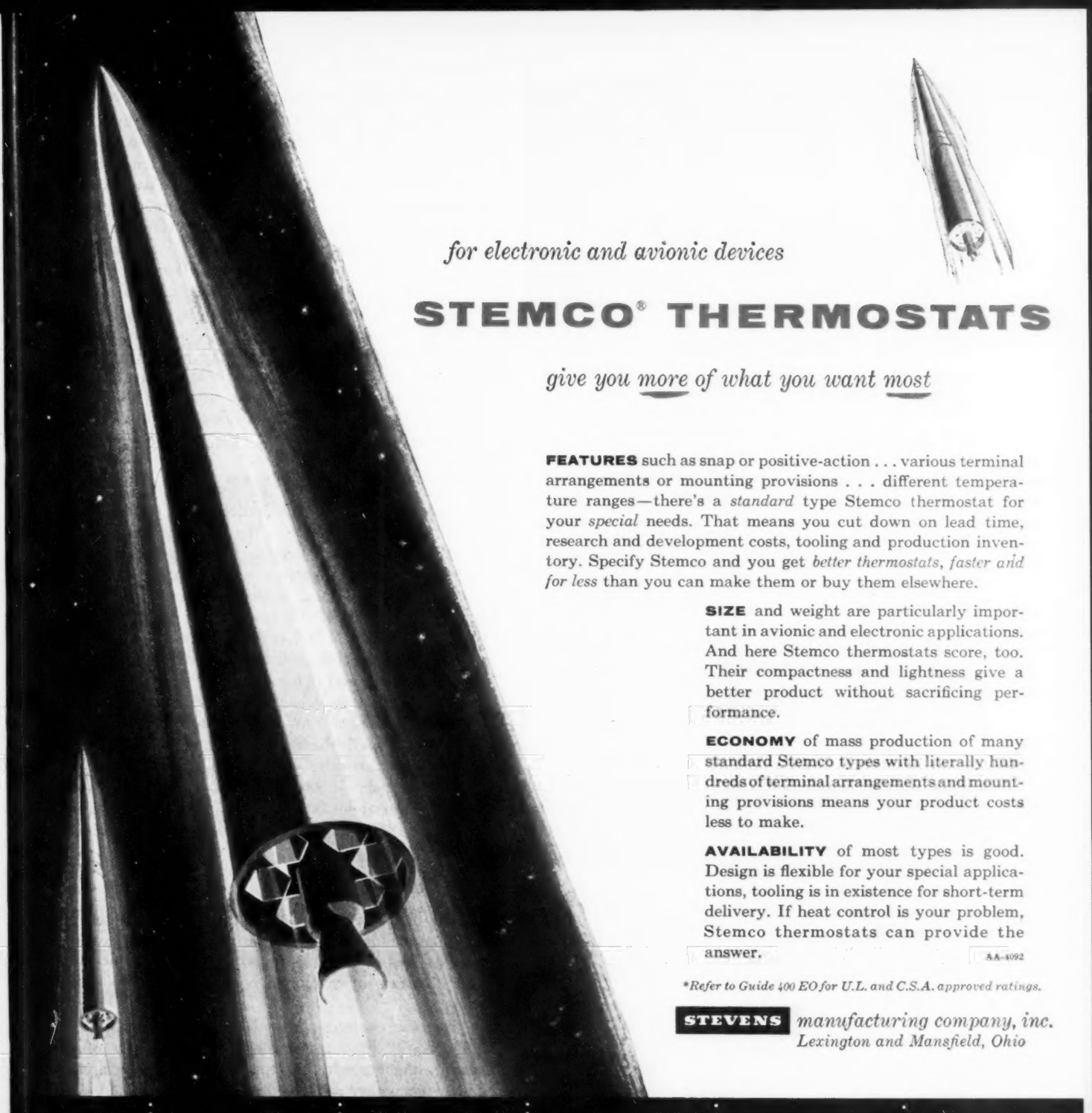
SHORTAGE DEFINED

In their report Blank and Stigler indicate that although the word "shortage" is seldom defined precisely they felt that the one most natural for them to use was that a shortage exists when the number of workers available increases less rapidly than the number demanded at the salaries paid in the recent past in a free labor market. Because of an increase in the supply of engineers, salaries have actually drifted downward in relation to the salaries of other workers.

The pronounced downward drift of earnings in all professions (except medicine) relative to earnings of the working population as a whole appears to be well known, according to the authors, and it is apparent that engineers have fully shared in this relative decline. This downward drift is known only for the period since 1921 but Blank and Stigler conject that it began much earlier because the main force working in this direction—the rapid expansion of a number of trained professional workers—also began much earlier.

THE SCARCITY IDEA

After the outbreak of the Korean war, there was a minor increase in the relative salaries of engineers and of other college-trained workers, but this was hardly more than a minor cross-current in a tide. According to their statistics the record of earnings of engineers in comparison to the working population as a whole and to the professions as a separate class there has been no shortage of engineers up to at least 1955. In fact there has been an increasingly ample supply of engineers. The authors show that the



for electronic and avionic devices

STEMCO® THERMOSTATS

give you more of what you want most

FEATURES such as snap or positive-action . . . various terminal arrangements or mounting provisions . . . different temperature ranges—there's a *standard* type Stemco thermostat for your *special* needs. That means you cut down on lead time, research and development costs, tooling and production inventory. Specify Stemco and you get *better thermostats, faster and for less* than you can make them or buy them elsewhere.

SIZE and weight are particularly important in avionic and electronic applications. And here Stemco thermostats score, too. Their compactness and lightness give a better product without sacrificing performance.

ECONOMY of mass production of many standard Stemco types with literally hundreds of terminal arrangements and mounting provisions means your product costs less to make.

AVAILABILITY of most types is good. Design is flexible for your special applications, tooling is in existence for short-term delivery. If heat control is your problem, Stemco thermostats can provide the answer.

AA-4092

**Refer to Guide 400 EO for U.L. and C.S.A. approved ratings.*

STEVENS *manufacturing company, inc.*
Lexington and Mansfield, Ohio

TYPE A*
emi-enclosed

ted; electrically in-
ndent bimetal disc
fast response and
snap-action control.
ation from –10° to
° or higher on special
Various mountings
erminals. Average
g 6½ amps at 115
AC, 4 amps at 230
AC and 28 volts DC.
ulletin 3000.

TYPE A*
Hermetically sealed

Electrically identical to semi-enclosed Type A. Temperatures from –10° to 300°F. Various enclosures and mountings, including brackets, available. For appliance, electronic, apparatus applications. Bulletin 3000.

TYPE C
Hermetically sealed

Electrically identical to semi-enclosed Type C but sealed in crystal can. Also supplied as double thermostat "alarm" type. Turret terminals or wire leads. Request Bulletin 5000.

TYPE C
Semi-enclosed

Small, positive-acting. Electrically independent bimetal strip for operation from –10° to 300° F. Rated at approximately 3 amps, depending on application. Terminals and mountings to customer specifications. See Bulletin 5000.

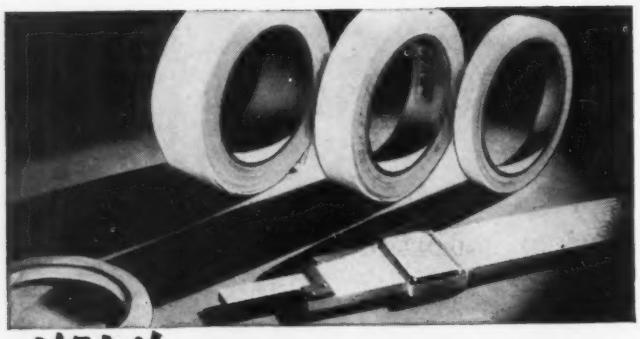
TYPE M*
Semi-enclosed

Electrically independent bimetal disc type for appliance and electronic applications from –10° to 350° F. Rating: 8-amps at 115 volts AC, 4 amps at 230 volts AC and 28 volts DC. Virtually any type terminal. Bulletin 6000.

TYPE M*
Hermetically sealed

Electrically same as semi-enclosed Type M. Can be furnished with pin or solder-type terminals, wire leads and various mounting brackets. Write for Bulletin 6000.

® STEMCO THERMOSTATS



NEW! Colored TEMP-R-TAPE®

Pressure-sensitive TEFLON tape for —100°F to 400°F applications*

Temp-R-Tape, easy to apply TEFLON tape with pressure-sensitive silicone adhesive, can now be ordered from stock in colors. Use: color coding. Regular white Temp-R-Tape is available from stock. Use: CLASS H insulation or low friction facing. (For example: slot lining, coil wrapping, harness bundling, wire splicing, etc.) Temp-R-Tape fits tight over sharp bends and compound surfaces. 1500 vpm dielectric strength. .006″ and .013″ thicknesses. .006″ only in colors.

**duPont trademark*

FREE SAMPLES and folder—write, phone or use inquiry service.

CONNECTICUT HARD RUBBER

NEW HAVEN 9 **CHR** CONNECTICUT

AIRFRAME SEALS · SILICONE RUBBER COATED FABRICS · SILICONE RUBBER SHEET & SPONGE · MOLDINGS & EXTRUSIONS

FOR MORE INFORMATION CIRCLE 99 ON INQUIRY CARD

GREEN ENGRAVERS *are fast!*

- Spindle speeds up to 26,000 rpm to engrave or for machining modern materials
- Fastest possible copy set-up
- Greatest ease and speed of adjustments
- Cutter grinders, rotary tables, master letters, compound slides, name plate blanks and all required accessories

MODEL D2 HEAVY-DUTY 2-DIMENSIONAL

- 575 pounds-rigid, sturdy, precise
- Vertical adjustment of copy table automatic with Pantograph
- Unobstructed on three sides to take large work
- Vertical range over 10 inches
- Micrometer adjustment for depth of cut
- Ball bearing construction throughout — super precision ball bearings in spindle
- Ratios 2 to 1 to infinity — master copy area 26″ x 10″

MODEL 106 PORTABLE BENCH MODEL- 2- OR 3-DIMENSIONAL

- 40 pounds of unbeatable speed and accuracy at a reasonable price
- Perfect for all machining applications within its range
- Ball bearing spindle has three speeds up to 14,000 rpm
- 5 positive, accurate pantograph ratios
- One copy carrier (supplied) accepts all master sizes
- Height of pantograph and position of cutter are continuously adjustable
- Work up to 10″ by any width
- Taper shank cutters

GREEN INSTRUMENT CO., INC.

365 Putnam Avenue Cambridge, Mass.

FOR MORE INFORMATION CIRCLE 101 ON INQUIRY CARD

to at least 1955. In fact there has been an increasingly ample supply of engineers. The authors show that the number of engineers has been growing more rapidly relative to the demand in the past two and a half decades than has been the case in the labor force as a whole; they expect this trend to continue in the future.

The only basis they find for popular view that there was a shortage of engineers after 1950 is related to the expansion of military procurement after the outbreak of the Korean war and the associated increase in government expenditures for both public and private research. The main effect of this short reversal seemed to be the popular acceptance of the idea of a serious and basic scarcity of engineers. Although there may be temporary shortages of personnel in certain geographic areas or specific professional skills, they found no evidence of any shortage of substantial magnitude.

NUMBER OF ENGINEERS BY 1970

Projections in the study indicate that if there is only a moderate rate of increase in the proportion of persons aged 22 graduating from college and a maintenance of approximately the current degree of concentration on engineering among such graduates, engineering schools will graduate roughly 33,000 to 36,000 engineers in 1960 and 60,000 or more engineers in 1970. If the proportion of men aged 22 graduating from college rises in the next fifteen years as it has since 1930, and if the degree of specialization in engineering increases as it has since 1930, the number of graduating engineers in 1960 will be over 40,000; the number in 1970 will reach the staggering total of 90,000. The most conservative estimates yield an indicated total of college-trained engineers in 1965 of about 720,000, contrasted to a 1950 total of about 300,000. The high estimates lead to an indicated 1965 total of about 820,000 college-trained engineers.

FACT VS. FANCY

This publication is the latest and most authoritative analysis that has been brought to our attention. It answers probably as best as possible questions pertaining to the supply and demand of scientific personnel hitherto speculated about:

- Has the enormous growth in the number of engineers and chemists taken place in a few industries of unusual technical complexity, or throughout the industrial sector of our economy?
- What impact has been exerted by the expansion of governmentally financed research?
- How can we judge whether the growth in scientific personnel—physicists and mathematicians, as well as engineers—has kept pace with the rising demand?

Fragmentary and sometimes inconsistent evidence has hindered judgment on these questions. Drs. Blank and Stigler clarify the questions and identify the factual aspects bearing on the economics of the problem. Their conclusions will unquestionably create some furor in their attack on the popular belief of a severe shortage of engineers, present and future.

David M. Blank is associate economic advisor of Columbia Broadcasting System. George J. Stigler is a member of the research staff of the National Bureau of Economic Research, and Professor of Economics at Columbia University.

Advertiser's Index

ADVERTISER	PAGE NUMBER	INQUIRY NUMBER
A		
Ace Electronics Associates, Inc.	45	38
Acton Laboratories, Inc.	32	27
Alden Products Co.	22	16
American Metaseal Corporation	54	100
American Sealants Co.	116	92
Assembly Products, Inc.	103	79
Atlas E-E Corporation	59	47
Austenal Inc., *Microcast Division*	31	25
Automatic Switch Co.	105	83
Autron Engineering, Inc.	80	69
B		
Baker & Co., Inc.	57	45
Barksdale Valves, *Pressure Switch Division*	128	108
Bendix Aviation Corporation, *Eclipse-Pioneer Division*	21	14
Bendix Aviation Corporation, *Pacific Division*	83	72
Bendix Aviation Corporation, *Scintilla Division*	27	20
Bishop Manufacturing Corporation	81	70
Brooks & Perkins, Inc.	46	39
Brush Electronics Company, *Division of Clevite Corporation*	6-7	4
Bulova Watch Company, *Electronics Division*	75	65
B W Controller Corporation	120	96
C		
The Chemical Corporation	20	15
Chemiquip Co.	59	49
Chrysler Corporation, *Amplex Division*	69	60
Circle F Mfg. Co.	37	33
Clarage Fan Company	101	78
The Clark Controller Company	87	75
Clifton Precision Products Co., Inc.	Cover 4	110
Composite Forgings, Inc.	63	53
Computer-Measurements Corp., *Subsidiary of Hancock Manufacturing Co.*	107	84
Connecticut Hard Rubber	122	99
Continental-Diamond Fibre, *A Subsidiary of the Budd Company*	8	5
Continental Wire Corporation	86	74
Cosmo Plastics Company	19	12
D		
The Daven Co.	39	35
Detroit Controls, *Division of American-Standard*	110	86
Detroit Stamping Company	112	88
Diamond Antenna & Microwave Corp.	33	29
Dumetallic Corporation	19	13
E		
Electro-Mechanical Products Co.	73	64

Free Technical Bulletin on Surface Measurement

gives all the meat of ASA Standard B46.1-1955 on surface roughness, waviness and lay, plus helpful supplementary material. Arranged for easy reading and convenient reference. Includes these sections:

- Basic definitions — with profile records of typical surfaces.
- How to designate the characteristics of roughness, waviness and lay, on drawings.
- How to measure those characteristics.
- Arithmetical and r.m.s. average roughness height.
- How the Profilometer® measures average roughness height.
- Instrument characteristics for roughness measurement — as specified by the standard, and as provided by the Profilometer.

It's timely — authoritative — comprehensive. Write today for *BULLETIN LT18.*

Profilometer is a registered trade-mark.

MMC® MICROMETRICAL MANUFACTURING COMPANY

357 S. MAIN ST., ANN ARBOR, MICHIGAN

FOR MORE INFORMATION CIRCLE 102 ON INQUIRY CARD

SAVE TIME-MONEY

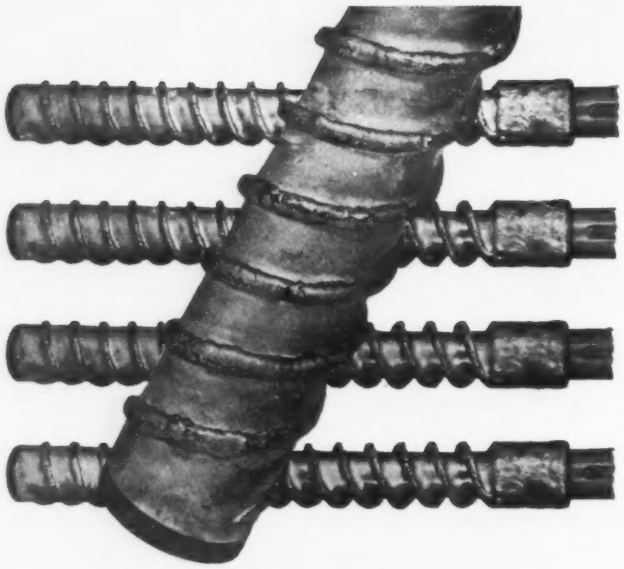
replace bearings on-the-job without dismantling! Made of long-wearing Sabeco Bronze, patented Sabeco Split Thrust Replacement Washers slip on the shaft and lock with the safety key to provide dependable replacement in minutes! Supplied in any practicable size to your specifications. Write today to Dept. EMD for additional information.

Slipper Shoes of Sabeco Bronze wear longer!

sabeco SAGINAW BEARING CO.

821 S. WATER SAGINAW, MICHIGAN

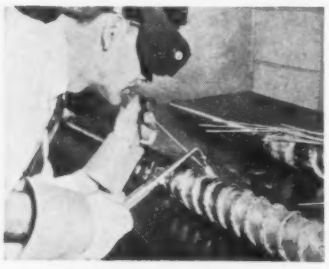
FOR MORE INFORMATION CIRCLE 103 ON INQUIRY CARD



Colmonoy INCREASES Extrusion Screw Life

Tests revealed a tremendous increase in the service life of these Colmonoy hard-faced extrusion screws, as against the unprotected screws usually used. Orders for new replacements now specify Colmonoy hard-facing.

Used for extruding plastic, these screws are made of age-hardening nickel-base alloy. This alloy is now readily hard-faced with little loss of hardness, using Colmonoy No. 6 gas rod and a new Colmonoy high temperature flux.



The 60-inch screws have a .050″ overlay of Colmonoy No. 6 when finish ground. Colmonoy hard-facing pays for itself in increased life very quickly on expensive parts such as these.

To provide any metal part with longer life, investigate Colmonoy alloys and methods. They represent a complete line of wear resistant alloys and the most up-to-date in hard-facing techniques.

Submit part drawings and a description of the wear encountered for a specific recommendation. Request Hard-Facing Manual No. 79.

HARD-FACING ALLOYS

19345 JOHN R STREET **WALL COLMONOY** DETROIT 3, MICHIGAN

CORPORATION

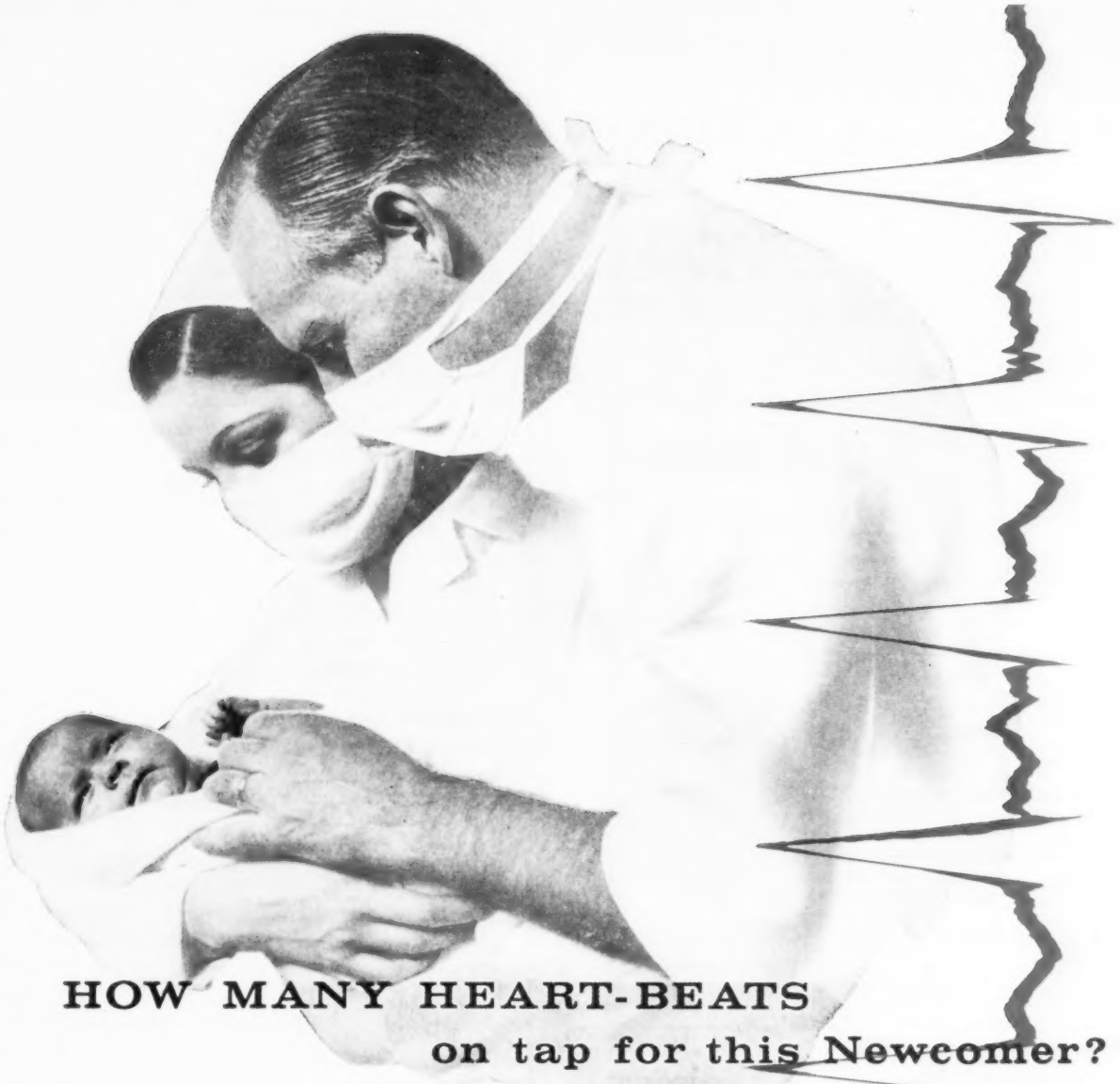
BIRMINGHAM • BUFFALO • CHICAGO • HOUSTON • LOS ANGELES
MORRISVILLE, PA. • NEW YORK • PITTSBURGH • MONTREAL • GREAT BRITAIN

FOR MORE INFORMATION CIRCLE 104 ON INQUIRY CARD

Advertiser's Index

ADVERTISER	PAGE NUMBER	INQUIRY NUMBER
Electro-Switch Corporation	114	90
Charles Engelhard Incorporated	41	37
Epoxy Products, Inc. *A Div. of Joseph Waldman & Sons*	49	40
ESC Corporation	35	31
F		
Fenwal Incorporated	2	2
Fidelity Chemical Products Corp.	59	50
The Franklin Dales Co.	30	23
G		
Gabriel Co., *Gabriel Electronics Division*	126	106
General Controls Company	30 103	24 81
General Electric	55	44
General Radio Co.	67	58
Gibson Electric Company	32	26
Grant Pulley & Hardware Company	71	62
Green Instrument Co., Inc.	122	101
Gries Reproducer Corp.	33	28
G-V Controls Inc.	4	3
H		
H.F. Hanscom & Co., Inc.	63	55
Hartford Steel Ball Co., Inc.	66	57
The A.W. Haydon Company	111	87
Heli-Coil Corporation, *A Division of Topp Industries, Inc.*	10 & 11	7
Howell Electric Motors Co.	85	73
I		
Industrial Tectonics, Inc.	15	8
Interelectronics Corporation	61	51
L		
Lambda Electronics Corp.	97	77
Lavoie Laboratories, Inc.	16	9
Lermer Plastics, Inc.	63	54
M		
Magline Inc.	115	91
The R.C. Mahon Company	72	63
Maxson Instruments Corporation	34	30
Mechanical Rubber Products Co.	22	17
Micrometrical Manufacturing Company	123	102
Morton Bearing Company	51	42
N		
NJE Corporation	23	11
Numatics, Inc.	117	93
P		
Panoramic Radio Products, Inc.	17	10
Peters-Dalton Inc., *Subsidiary, Detroit Harvester Co.*	82	71

Index continued page 124



HOW MANY HEART-BEATS on tap for this Newcomer?

What will the life span be for this young fellow—will his life be happy or hard, long or short? How many times, actually, will this new heart beat?

Answers to questions like that aren't just guesses any more . . . they can be computed, far in advance, with an amazing degree of accuracy.

Those marvelous electronic mechanisms called *computers* have opened a new volume of information about our world, our life, and ourselves in general. And new chapters keep registering on the computer consoles.

The terrific speed with which complex calculations whip through the computers continues to challenge the comprehension. And the basic principle of the computers—of working with electrical charges that are *exactly* proportional to the figures involved—continues to require a power supply that is uniform, unvarying, and dependable. This demand is increased by the move to miniaturize the computer—get it down to a less cumbersome size by using smaller components all the way through to produce the same, or better, results.

Computer designers had a problem . . . until they called in Sorensen. Sorensen is the authority on *controlled power for research and industry*, the world's leading maker of precision electronic voltage regulators. When Sorensen engineers collaborated with the computer design people, new solutions to the power problem were found. Sorensen "resonant regulators", in special circuitry for computer needs, are now providing surge-free power for leading makes of computers.

If you have problems of devising a "smooth" power source, AC or DC, for "plug in" apparatus or major installations, consult Sorensen, the power specialists.

SORENSEN & COMPANY, INC. Richards Avenue, South Norwalk, Connecticut

Sorensen®

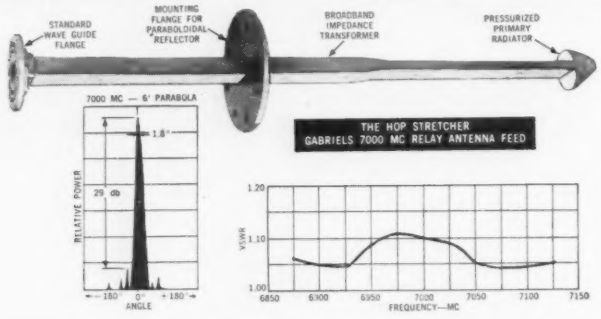
FOR MORE INFORMATION CIRCLE 105 ON INQUIRY CARD

Gabriel
ELECTRONICS DIVISION

New Products

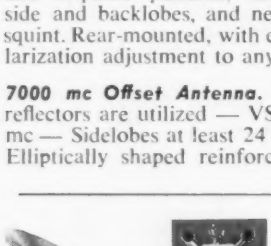
The HOP-STRETCHER feeds offer higher gain, lower sidelobe levels and more desirable beam-widths for center-fed parabolic antennas. This feed was developed for S, X, K_u and K_a bands.

Technical features of X-band antenna • Sidelobes at least 24 db down on 4, 6, 8 and 10 ft. reflectors • High gain efficiency, 65-70%

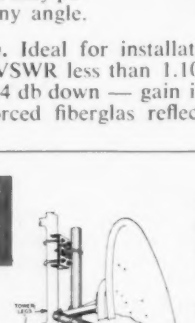


The new hi gain 3 kmc Cylindrical Coaxial Feed provides similar E and H-plane patterns, minimum side and backlobes, and negligible squint. Rear-mounted, with easy polarization adjustment to any angle.

7000 mc Offset Antenna. Ideal for installations where passive reflectors are utilized — VSWR less than 1.10:1 over 5900-8500 mc — Sidelobes at least 24 db down — gain is 41 db at 7000 mc. Elliptically shaped reinforced fiberglas reflector.

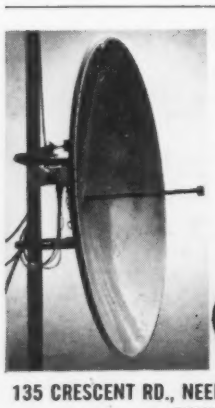


The new X-band parabolic antenna with standard feed. Features variable polarizing adjustment, 0 to 90°. Manually locked in position.



The new universal 3-point suspension mounting bracket for 2, 4, 6, 8 and 10 ft. parabolic reflectors.

Features • Independent azimuth adjustment. • Independent elevation adjustment. • Adaptable for mounting in all locations.



GABRIEL'S MICROWAVE PARABOLIC ANTENNAS

. . . Contributing millions of trouble-free operational hours for industry and the military.

- 7000 mc — Broadband (5925-7425 mc) high gain > 40 db low sidelobes — low VSWR < 1.13:1 over band.
- 4000 mc — Narrow-beam broadband (3700-4200 mc) — low VSWR < 1.2:1 — gain > 37 db.
- 2000 mc — Available in offset and center-fed feeds. Narrow-beam broadband (1750-2110 mc) — high gain > 28 db low VSWR < 1.3:1 over band.
- 940 mc — All weather radome covered feed — gain > 22 db low VSWR < 1.25:1.

Gabriel

135 CRESCENT RD., NEEDHAM HEIGHTS 94, MASS. - phone NEedham 3-0005

CIRCLE 106 ON INQUIRY CARD

Advertiser's Index

ADVERTISER	PAGE NUMBER	INQUIRY NUMBER
George A. Philbrick Researchers, Inc.	Cover 2	111
Pix Manufacturing Co., Inc.	40	36
Potter Aeronautical Corp.	113	89
Potter Instrument Co., Inc.	77	67
Printed Electronics Corporation	119	95
R		
Raytheon Manufacturing Company, *Commercial Equipment Division*	79	68
Raytheon Manufacturing Co.	9	6
Revere Copper and Brass Incorporated	64 & 65	56
Robinson Aviation Inc.	109	43
S		
Saginaw Bearing Co.	123	103
Servo Corporation of America	25	18
H.B. Sherman Manufacturing Company	51	41
Simmonds Aerocessories, Inc.	28	21
Sorenson & Company, Inc.	125	105
Sparta Manufacturing Company, *Division of United States Ceramic Tile Co.*	26	19
Sprague Electric Co.	1	1
J.S. Staedtler, Inc.	36	32
Stevens Manufacturing Company, Inc.	121	98
Stonite Coil Corporation	118	94
T		
Taylor Electric, Inc.	68	59
Technology Instrument Corp.	58	46
Tempo Instrument Incorporated	103	80
Therm-O-Disc, Inc.	70	61
Thompson Products Inc., *Electronics Division*	29	22
U		
United Electric Controls Co.	127	107
The United States Graphite Company, *Division Wickes Corp.*	Cover 3	109
V		
Veet Industries	63	52
The Victoreen Instrument Company, *Components Division*	108	85
W		
Wall Colmonoy Corporation	124	104
Charles F. Warrick Co.	103	82
Waters Manufacturing, Inc.	96	76
John C. Whiddett Co.	120	97
Edwin L. Wiegand Company	59	48
Y		
Yardney Electric Corporation	38	34

MANAGEMENT

MARTIN KAGAN
Executive Vice President, Yardney Electric Co.

WESCON: Fatted Calf at the Cow Palace

Only a short while ago the Cow Palace, San Francisco, was the scene of history-generating political conventions. More recently on August 21st through 23rd at the same palace the very devices by which those conventions were made accessible to a nationwide watching and listening audience were themselves the object of close scrutiny, along with those developments that make guided missiles, radar and electronic computers common conservation items of our times. The show reviewed the progress of the electronic sciences and industries over the last fifty years, progress reaching toward new frontiers with a youthful, pioneering push. This push characterized WESCON giving it a westward-ho spirit.

Informal candidness and open curiousity, often sighted as peculiarly abiding west-coast virtues, were infectiously shared by all the spectators regardless of their geographic origins. Easy and friendly exchanges among the spectators and between the spectators and the show managers made it a very democratic forum.

Visiting Soviet engineers, easily caught up in the participating inquisitive spirit, nowhere stood out as anomalies. They delivered papers in the fields of molecular structures, spectroscopy and magnetic resonance phenomena, fields, they said, in which they considered themselves advanced in comparison with us.

It was electronic advances that people came to see, advances in theory and application since Roentgen discovered X-rays (1895) and Fleming patented the diode (1904) and Dr. Lee De Forest shortly thereafter on the west coast developed the three-electrode tube, the audion, to transmit the human voice undiminished across seas and continents.

GROWTH OF THE WESTERN WALLET

The west coast's widespread and penetrating enthusiasm for matters electronic is readily understandable. The enthusiasm is tinged with dollar green—the blush of prosperity. Slightly more than a decade ago the west coast shared only one per-cent of the business in electronics; today twenty to twenty-five per-cent of the electronics business is concentrated there—a lion's share of several billions of dollars, and the show radiates even greener, glowing promise.

GREAT EXPECTATIONS

Sharply contrasted with this confident and independent spirit often expressed in the technical forum was the pres-

REMOTE BULB, INDICATING TEMPERATURE CONTROL E32N

Featuring Control Point Accuracy Equivalent to Individually Calibrated Instruments

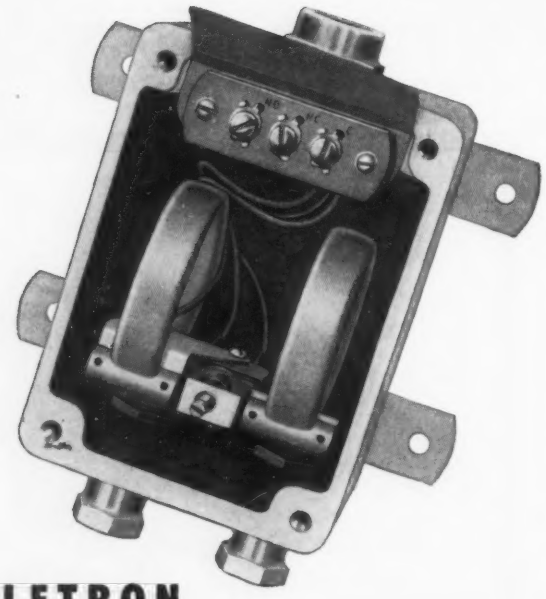
The **UNITED ELECTRIC** Type E32N Temperature Control is a uniquely designed instrument that is used to control and indicate temperatures of gases, liquids or hot plates over wide ranges. This unit contains a 12-inch scale for easily read visual indications. It is possible to replace the thermal unit in the field without any loss of calibration accuracy.

Temperature Ranges....	—150°F. to 150°F., 70°F. to 370°F., 100°F. to 650°F. Read temperature on continuous, 12-inch indicating scale that rotates against a fixed index pointer in a vertical and centered location.
Switch Ratings.....	Up to 15 amps. at 115 or 230 volts A.C. 20 amp. A.C. or D.C. switches also available.
Switch Types.....	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential.....	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment.....	Calibrated dial rotated against a fixed index.
Calibration.....	Calibrating mechanism permits precise matching of scale to individual tolerance errors of thermal assemblies.
Compensation.....	Automatic compensation for ambient temperatures.

SEND FOR NEW Catalog 200 for full information on the E32N and other remote bulb temperature controls.

UE® United Electric Controls COMPANY
82 SCHOOL STREET, WATERTOWN, MASS.

CIRCLE 107 ON INQUIRY CARD



MELETRON

DIFFERENTIAL SWITCH

senses pressure differences from 4 to 9000 p.s.i.

with Proof Pressures ranging from 500 to 12,000 P. S. I.

A good illustration of this switch function is its application on multiple stage compressors. If a failure occurs in one of the stages the switch will signal the pressure difference change or shut down the system to prevent damage.

EXTREMELY ACCURATE

Simplicity of direct acting design plus rugged precision construction make for long, unchanging repeat accuracy.

Note, that we don't use

LINKAGES AND BEARINGS

which, as they wear, cause settings to drift.

IN ANY POSITION

on moving equipment, even under vibration, switch performs with equal efficiency.

Because we don't use

LIQUID SWITCH ELEMENTS

which require that the pressure switch be mounted absolutely vertical, which make it very critical to vibration.

To get complete operating characteristics and specifications ask for bulletin 532

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

CIRCLE 108 ON INQUIRY CARD

ent dependence on the military budget immediately apparent in the business exhibits. The preponderance of military equipment on display was even more marked than it has been in east coast conferences. The prevading spirit of optimism is remarkable in the face of threatened cutbacks in this military market. Does it reflect a determination to be identified not only with the defense of present values but also with the promise of a more abundant and better tomorrow?

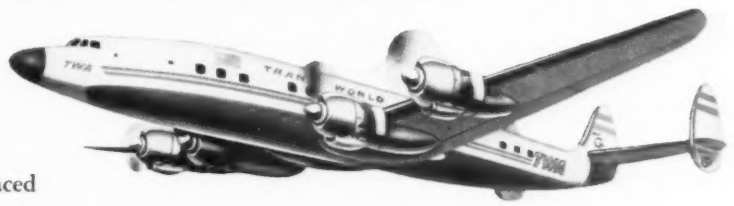
TWO IMPORTANT DEVELOPMENTS

The show could boast a large number of technical papers. From five hundred submitted about two hundred and twenty-five were selected. Among developments reported two stand out for their promise to the future: a new radiation technique for medical application and a 50-watt power transistor. The new radiation technique, in contrast to the method it aims to displace, produces no undesirable side-effects in the patient, making treatment a brief interlude in the patient's work-a-day pattern of life; a short visit periodically is all that is required and immediately after the visit the patient may resume his normal activity. The announcement of a 50-watt power transistor, just ten years after the first germanium units were developed, pushes transistors ahead into many fields hitherto not considered within their scope. A high voltage a-c or d-c source generated from a 3-, 6-, or 12-volt commercial battery can be obtained by use of high-power transistor circuitry. This technique can now produce power packages rated to several kilowatts, sufficient to run a radio for five or six hours or possibly a television set.

Two interesting sidelights indicating the electronic industry's awareness of its influence and responsibility in the social life were: a special exhibit of paintings with electronic themes and a future engineer's show exhibiting the works of winners of a contest among engineering students from six western states. Both exhibits well attended and well received gave the show additional color and substance.

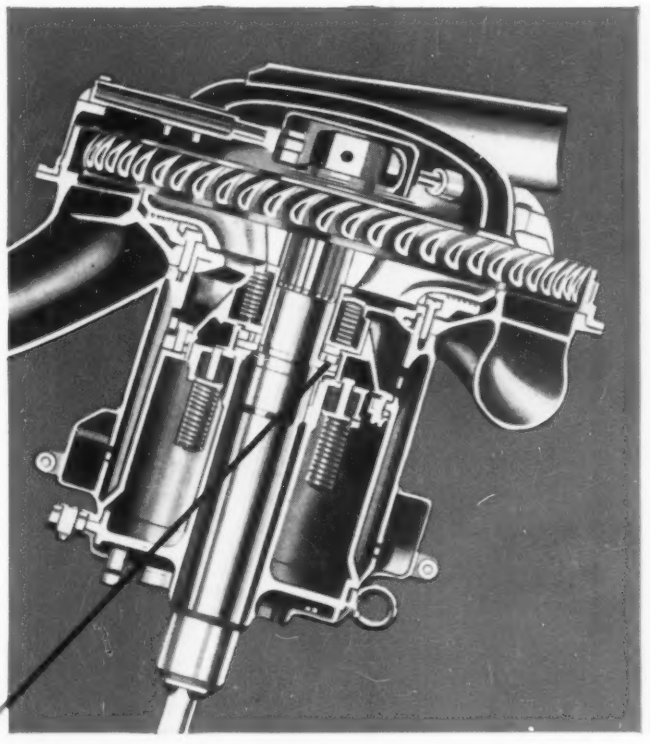
"Oh, it doesn't do anything, it just gives me something to do"

GRAPHITAR® OIL SEALS PLAY IMPORTANT PART IN DEPENDABLE PERFORMANCE OF NEW POWERFUL CURTISS-WRIGHT TURBO COMPOUND ENGINES



Increased demand for faster non-stop service has placed great demands on the engines that power modern airliners. Helping to meet this need is the powerful EA Series Turbo Compound engines built by the Wright Aeronautical Division of the Curtiss-Wright Corporation, Wood-Ridge, New Jersey. In each of these 18-cylinder giant engines, 3 GRAPHITAR oil seals play an important part in maintaining the dependability, efficiency and power. Three power-recovery units are employed on the Turbo Compound to utilize normally wasted exhaust gases and provide still additional thrust. The GRAPHITAR seals are used on the turbine shaft in each of these units and must withstand continuous high speeds and high temperatures. These seals prevent hot gases from reaching the shaft bearings and carbonizing the lubricant. Low coefficient of friction, and the excellent wear and sealing properties of GRAPHITAR make it ideally suited for this demanding installation.

Compacted under extreme pressure, and fused at heats to 4500° F., GRAPHITAR can be formed into relatively complex shapes, ground to tolerances as close as .0005". Since it is entirely self-lubricating, GRAPHITAR can be used where only steam or water are present. GRAPHITAR is lightweight, durable, chemically inert and virtually unaffected by extremes of vibration, pressure, or temperature.



Get the fact-filled GRAPHITAR engineering Bulletin No. 20. Write today for your copy. If you have design questions on problems, our engineering staff will be happy to assist you in any way possible.

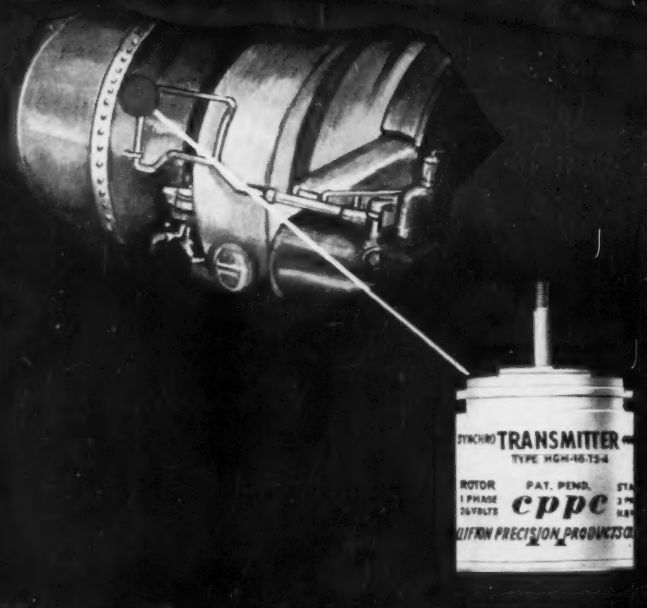
R-248-1

THE UNITED STATES GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 24, MICHIGAN

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® SINTERED METAL PARTS • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

FOR MORE INFORMATION CIRCLE 109 ON INQUIRY CARD



HIGH TEMPERATURE RESISTANT SYNCHROS

HIGH ACCURACY at 450°F

These size 10 high temperature resistant stainless steel synchros are available as transmitters, transformers, differentials and resolvers.

The transmitter was developed for direct turbo jet engine mounting and has passed tests at 450°F for 100 hours and 350°F for 1000 hours.

CLIFTON PRECISION PRODUCTS CO., INC. Clifton Heights, Pa.